MINING ENGINEERING

NOVEMBER 1949

Incorporating
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MINING TECHNOLOGY
COAL TECHNOLOGY

MINING ENGINEERING

VOL. I NO. 11 NOVEMBER 1949

In This Issue

COVER

Putting a timber cap in place at the Homestake Mining Co., Lead, South Dakota.

Published by the Mining Branch, AIME to provide a continuing, authoritative, and up-to-date record of technologic, engineering, and economic progress. The American Institute of Mining and Metallurgical Engineers, 29 West 39th Street, New York 18, N. Y.

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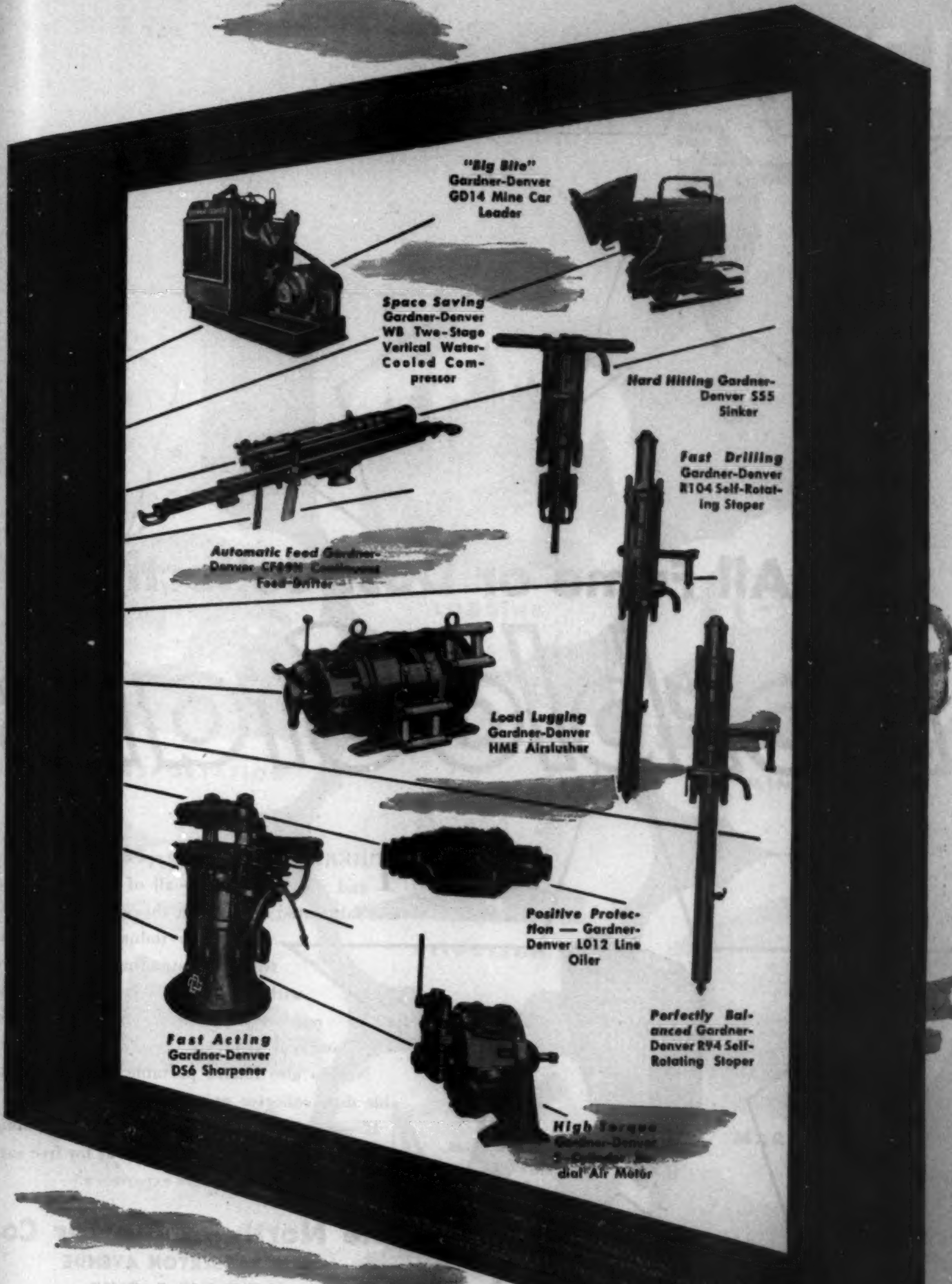
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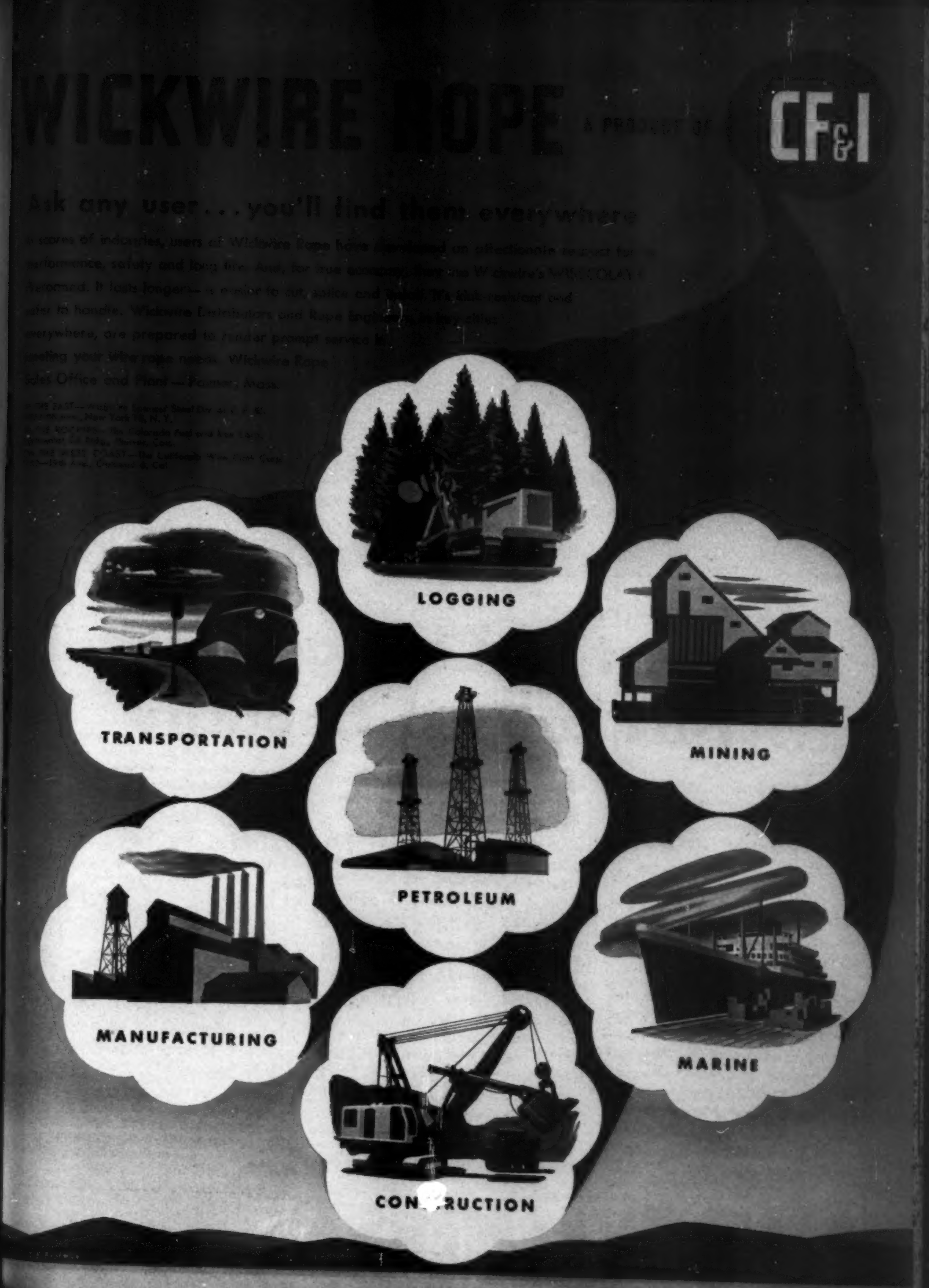

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Authors in This Issue

R. S. Mason

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C. P. Heiner

J. A. Brusset, author of "Diesel Proves Safe in Coal Mine" on p. 40, is vice-president of West Canadian Collieries, Ltd., in Blairmore, Alta., Canada. A mining engineer, he was born in St. Just, France, attended high school in Grenoble, and took his degree from the Ecole des Mines in St. Etienne. He was with the Mines de Lens in France before coming to Canada. Now lives in Montreal, and enjoys riding and skiing in his spare time. . . . **Russell G. Haworth,** ass't resident manager for the Potash Co. of America in Carlsbad, N. M., tells us about "Mining Potash Ores in the Carlsbad Area" on p. 381 of this issue. Wyoming-born, he attended the Harvard Engineering School, taking a B.S. in mining engineering. Spent six years with Homestake and then was a mine superintendent in the Philippines. Mr. Haworth is an AIME Member, collects minerals in his spare time. . . . **Claude P. Heiner,** president of the Utah Fuel Co., has contributed "Economics of Coal for West Coast Power Generation" on p. 401. Born in Utah, Mr. Heiner spent his career there, except for the years spent getting an A.B. degree in Industrial Engineering from Columbia in 1926. An AIME Member, he lives in Salt Lake City, and enjoys fishing with his son when he's not on the job. . . . **Charles A. Lindberg,** who holds forth in our Open-Pit Forum this month with "Auxiliary Equipment for Truck Haulage Pits," has been with the Oliver Iron Mining Co. since 1919, is now supervisor of truck maintenance there. Born in Ironwood, Mich., he served as a second lieutenant in World War I. Mr. Lindberg enjoys the outdoor life, takes along rod, gun, and camera when he goes a-wandering. . . . **R. S. Mason,** co-author of "Lightweight Aggregate Industry in Oregon" on p. 385, has been a mining engineer with the Oregon State Dept. of Geology and Mineral Industries for six years, was formerly with the Rustless Mining Corp. Born in Hood River, attended the Univ. of Oregon and Oregon State, took a B.S. in geology. Joined the AIME in 1939. Mr. Mason indulges in mountain climbing, writes science articles for children's magazines, and is a member of the Geographical Society's committee on glaciers. . . . **Carrol A. Quam** explains how "Salt-Bath Hardening Increases Churn-Drill Bit Life," on p. 38. Born in Stoughton, Wis., he took a B.S. from Missouri School of Mines, M.S. from the Univ. of Alabama, served as an experimental officer on explosives with the Navy in wartime. Now ass't mine superintendent for the National Lead Co., and an AIME member, Mr. Quam is another spare-time devotee of rod, gun and camera. . . . **Russell S. Sage** came from Rose Polytechnic Institute in his native Terre Haute, Ind., to the General Electric Co. in 1907 with a B.S. in electrical engineering, and has since become an engineer in GE's mining division, supervising many and diverse industrial installations such as coal, metal mining, cement plants, including hoists, sinterers, ventilation, pumping, and ore preparation. Mr. Sage is an AIME member. . . . **N. S. Wagner,** field geologist with Oregon's state dep't of Geology and Mineral Industries, co-authored "Lightweight Aggregate Industry in Oregon" with R. S. Mason. A graduate of Cornell University, Mr. Wagner has his B.A. and M.A. from that school. AIME Member. His hobby is collecting antique firearms.

Louis Moyd, author of "A Simple Method for Making Stereoscopic Photographs and Micrographs," on p. 383, is a geologist with Minerals, Ltd., and now working in Bancroft, Ont., Canada. Born in Philadelphia, he attended Wagner Institute of Science and Bryn Mawr College. Since 1944 he has made extensive explorations of Ontario and the Northwest Territory in Canada; worked on mineral investigations for the Climax Molybdenum Co.; and headed the geology section for the Corps of Engineer's concrete research division in Clinton, Miss. He is now director of research and development for Minerals, Ltd., and a Junior Member of AIME.

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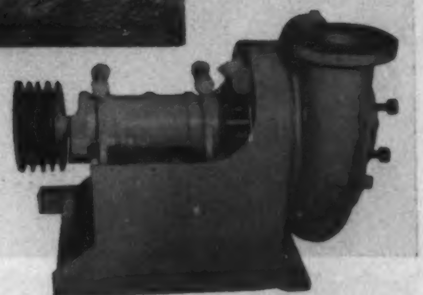

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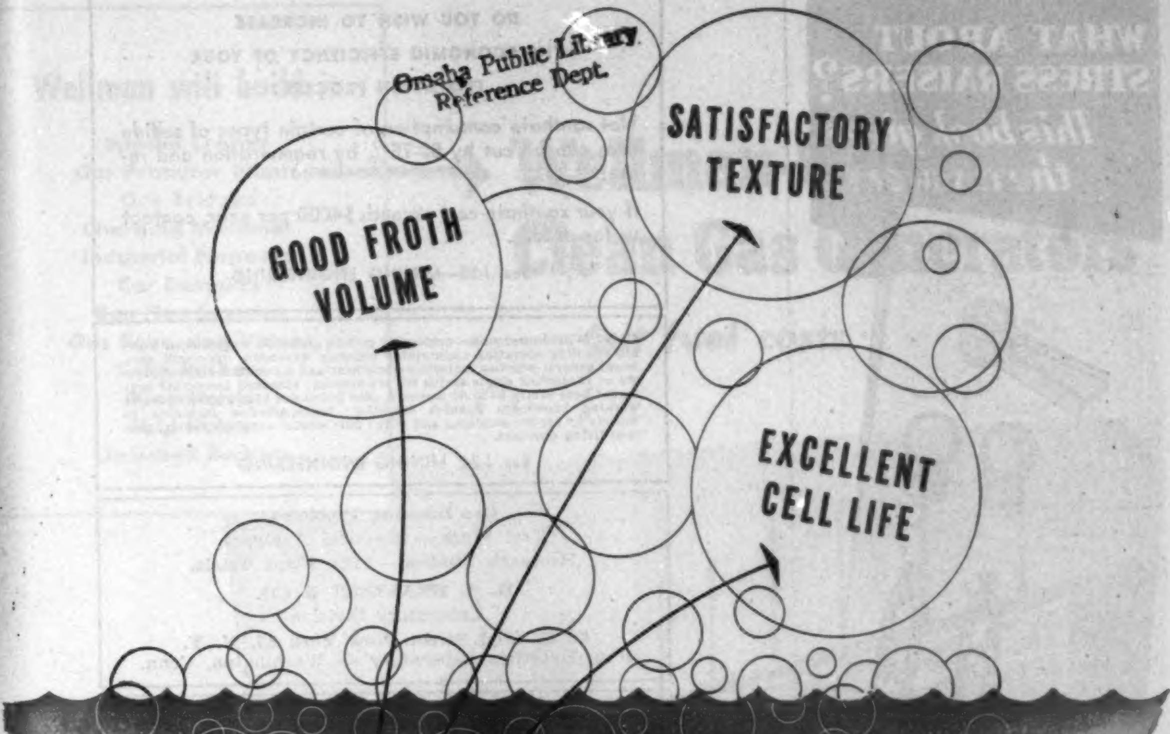
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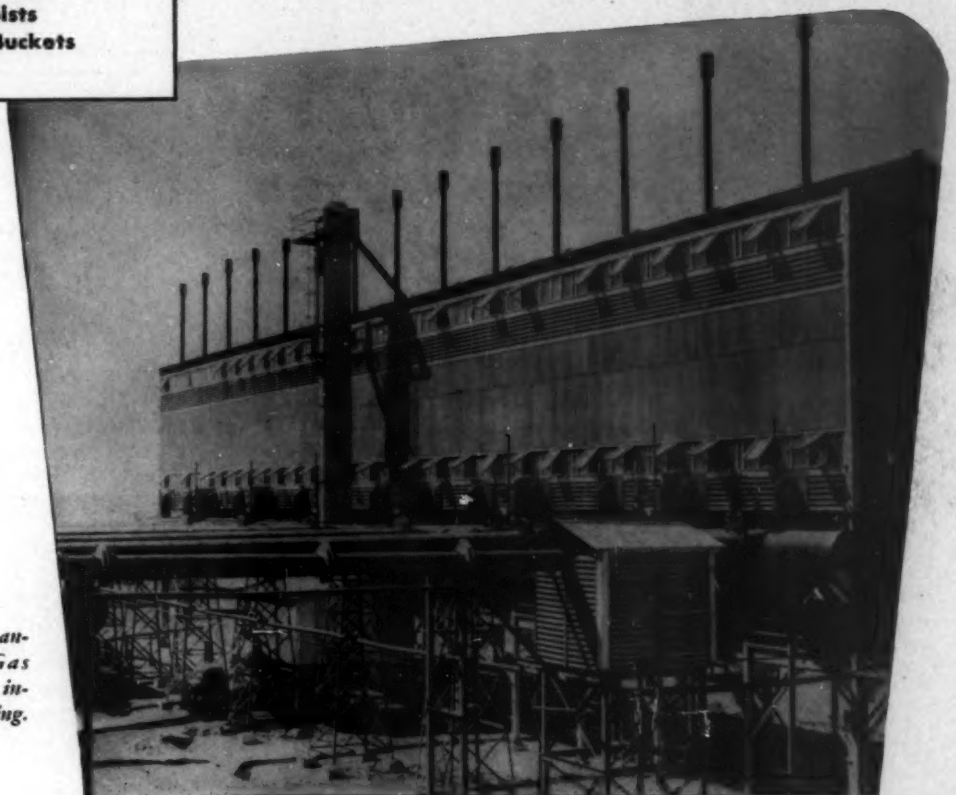

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2 *To produce directly a marketable concentrate* from fine material of low value.

EXAMPLE: *FINE IRON-ORE.* Pilot plant tests indicate the economic use of the Dutch State Mines Cyclone Separator, employing an autogenous medium, for the final concentration of fine sizes. Tests on certain iron ores on sizes above 48 mesh have shown recovery and grades higher than any other process now in use for treatment of $-3/16''$ materials.

3 *To treat fine feeds* which are inherently not amenable to jig or table treatment or cannot be economically concentrated by froth flotation.

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Mining Engineer to prepare from core drilling results reasonably accurate estimates of the extent, accessibility, quantity and quality of an ore deposit, for company starting exploratory core drilling on iron mining concessions. Location, Venezuela. Y-2852.

Mining Engineer, single preferred. Experience in supervision of development, operation and maintenance of gold dredging equipment for exploration project in British Guiana. Salary, $4800-$5400 plus expenses. Y-2875S.

New Blood and Our Mining Meetings

Being fresh from the crush of fall mining meetings and the attendant greetings of old friends and business associates, it occurs to us that pretty much the same crowd turns out each year for the respective affairs. From one standpoint this has advantages—one has the opportunity of building up acquaintanceships that are renewed from year to year, and the feeling of being lost in the crowd is dissipated after the first meeting or two. Also frequent attendance at meetings teaches one the ropes and makes it easier to get the meat out of technical sessions, policy making meetings, and individual discussions.

However, we may not be doing justice to ourselves and the organizations which we represent by exchanging information with the same circle of associates year in and year out. We offer the suggestion that "new blood" accompany the "old hands" to meetings. Meetings are held to disseminate technical information, to set policy on legislative matters, and to conduct business of the sponsoring organizations. On all these counts fresh ideas are needed. If a young man accompanied the experienced company meeting representative, he would absorb technical knowledge first hand. This would be advantageous because in many cases he is the man who works with these technical matters from day to day. We think advances in research would thus be brought to industry more quickly. These younger men also need to be indoctrinated in the many legislative problems that confront the mining industry. Thinking on such questions as tariff barriers, land reforms, taxation, and labor problems should be begun early and with the benefit of open discussion by mature thinkers. By being exposed to such discussion, they will be given food for thought which might be nurtured to fruition by the time they reach maturity in the company organization. Our professional societies also need young blood to carry on the many society functions, and this work might better be done by the younger men who are not weighted down with management responsibilities.

As mentioned in "The Drift of Things" in this issue, Petroleum Branch meetings have large attendance in which many young men participate. The petroleum industry has a way of training men so that they assume management responsibility relatively early in their professional careers. We in the mining business may well follow their lead by adopting positive training methods, and sending young men to meetings is good professional training. Thus, the companies which send young representatives to meetings would benefit by the assimilation of technical knowledge on the company level dealing with these aspects, by training men in the broader aspects of industry affairs, and by projecting their technical men into professional society work which will shed light on other problems and bring added knowledge.

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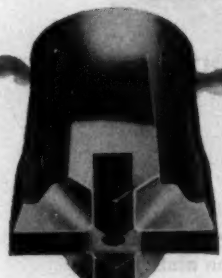

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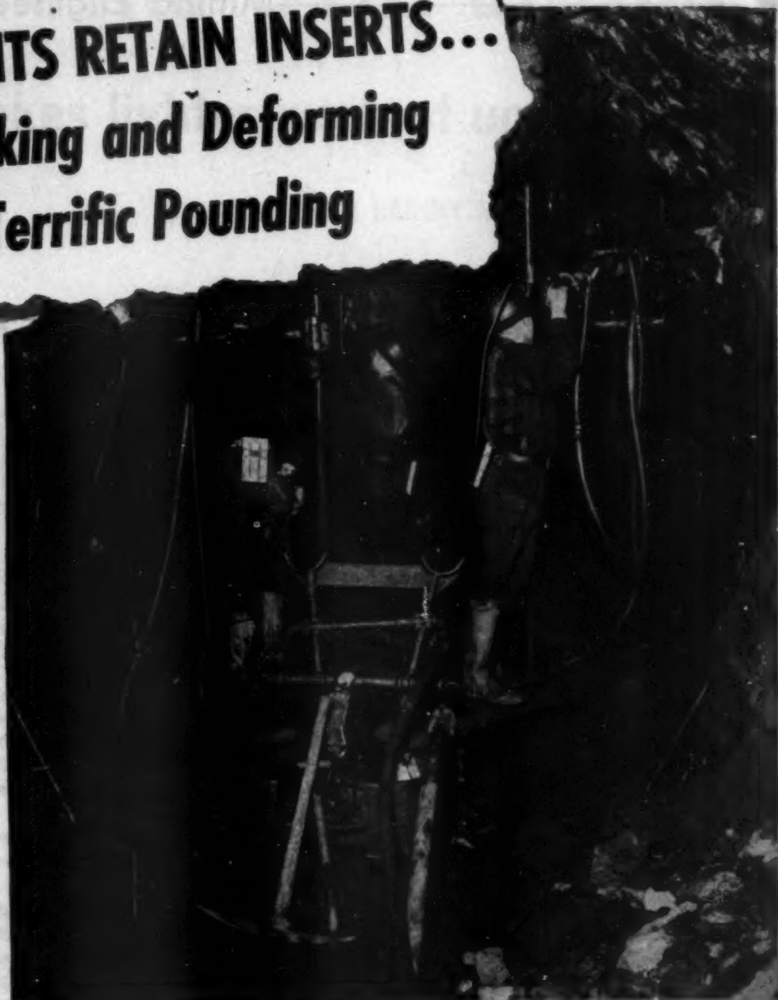

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* If the steel strike continues until Dec. 1, unemployment directly attributable to the strike will be approximately 5 million, says Secretary of Commerce Charles Sawyer. The upward trend in business and employment has been reversed by the strike.

* National Lead and Jones & Laughlin have increased the footage drilled with churn-drill bits by 50 pct and the drilling speed by about 12 pct by tempering bits by the electric salt-bath process (p. 38).

* High cost of building and operating an atomic power plant will keep nuclear power out of the industrial power field for some time to come, reported Ward F. Davidson at the joint Fuels Conference of AIME and ASME at French Lick Springs, Oct. 26. He estimated the first cost of a nuclear power plant at three times the cost per kilowatt of a coal-burning plant.

* Before the taxpayer can find relief from government armament and ECA spending, European recovery must be assured, commented Paul G. Hoffman. He suggests the importation of European goods as a means of speeding this recovery.

* Claude P. Heiner says that the use of Rocky Mountain coal for power generation in California is feasible even though it is presently more expensive than fuel oil (p. 388). He cites diminishing reserves of oil and gas in California and government supported hydroelectric plants as reasons for using coal for standby power generation in low-water years and in emergencies.

* The Erie Mining Co. applied in October to the Minnesota Department of Conservation to obtain a sufficient water supply for proposed beneficiation plants with capacity to produce up to 10 million tons a year of concentrated iron ore from taconite. Proposed plants would be located near Aurora, Minn.

* Secretary of Treasury, John W. Snyder, reiterated that the United States had no intention of changing the price of gold. He stressed that only Congress could change the $35-an-ounce price and that the Administration had no intention of requesting such action.

* Algoma Ore Properties, a subsidiary of Algoma Steel, has proved two new high-grade orebodies from which 12 million tons can be mined by open-pit methods before going to underground mining. The new discovery, known as Siderite Hill, is 3 miles west of Algoma's Helen mine and 100 miles north of Sault Ste. Marie.

* Near Morgantown, West Virginia, the world's largest coal conveyor system will soon be installed in a new bituminous coal mine. This conveyor belt will move 220 tons of coal an hour and it will move the coal through a two-mile tunnel from the mine's preparation plant to river docks.

* James Boyd recently announced that unlimited quantities of premium gasoline could now be produced from coal at a cost of only three or four cents a gallon more than the motorist now pays. A few plants could produce synthetic gasoline, at even lower cost, through the sale of by-product chemicals.

It's Everyone's Business

OCT. 25—Like an old-fashioned wrestling match, industrial conflict has become rather an unspectacular affair of powerful contestants locked in excruciating but static embrace. There's a twitch here and a grunt there, with bored onlookers patiently awaiting the violent flurry of the final fall. Such a formalized affair rarely rates the front page. Early in the month the epic conflict in Yankee Stadium and Ebbets Field captured the headlines and later in the month there was a certain fascinated attention accorded the military as they celebrated the second birthday of unification with a noisy civil war.

Elsewhere in Washington, the report of the Joint Congressional Committee on Atomic Energy relative to Mr. Lilienthal's "incredible mismanagement" was finding it difficult to see the light of day. Mr. Hickenlooper entirely failed to substantiate his charges and hearings long ago ceased for lack of witnesses. Hickenlooper is the current Washington word for fiasco, which must cause him great unhappiness, as the original intention was to so impress the folks back home in Iowa as to assure re-election in November 1950.

Congress, with adjournment at long last in prospect, hastily hacked through a log jam of unfinished business and was barely able to give more than passing attention to the swan song—replete with foreboding—of Dr. Edwin Nourse, President Truman's chief economic adviser. Dr. Nourse foresees possible economic ruin and he laid the blame for his apprehensions on high Government spending, the inevitability of more inflation and the preoccupation of management and labor with their own security.

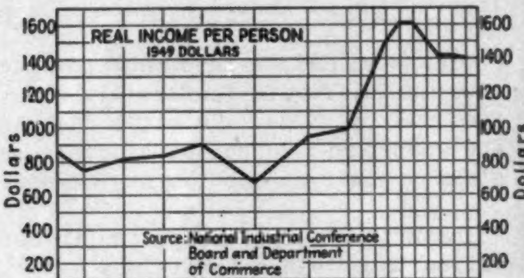
For the third time since the war the economy is being subjected to adverse events and developments of major magnitude. In 1945-46 the index of industrial production fell from 236 to 152, and in 1948 the index fell from 195 to a low of 162 in July 1949. In August there was a sharp recovery of 7 points and in September a few more points were added, but a chilling combination of blows in October pointed the index toward a new postwar low.

Indeed, the prospect of this decline has been enough to panic not only Dr. Nourse but quite a few other commentators. The prediction is that if current industrial strikes are not settled—and soon—the economy will slither into a quagmire of disaster. Many of these same commentators had been advocating a return to the bargaining table, but seem loath to accept the work stoppages that such a return entails. If the economy cannot stand these struggles for power it is indeed balanced on a thin edge, and the desire of many for government intervention to avoid such stoppages is symptomatic of the mental acceptance of the corporate-state philosophy.

It is true that the struggle for power between labor and management may well be reaching a particularly destructive stage. Furthermore, the basic position of the economy is undermined by very high taxes, the prospect of further levies for social insurance costs and disturbing dependence on unsound inflationary expenditure.

None the less, there is an underlying moderate tone of optimism among business men, civil servants and economists of various schools and connections. The war and postwar periods resulted in a buoyancy in investment that will not be lost for at least a few years yet. Financial reserves of individuals are still very high and are protected by social and private insurance and pensions. Large government expenditures serve to maintain both consumption and investment. Easy money is a pervasive stimulant. The economy contains no large area of over-extension or over-expansion to initiate a sizable collapse. And the increase in the population, which is far greater and more persistent than any estimates suggested, is another broad expansionary force.

Real income per person (see table) is now $1405 a year, which is almost double the level reached at the peak of the boom immediately following the first war and is 56 pct above 1929, 108 pct above 1933 and 41 pct above 1940. This 1949 figures indicates a standard of living of unprecedented abundance, and this has been realized despite the fact that nearly all segments of the community have been working



considerably under the level of efficiency permitted by existing skills and equipment.

On the labor-management front, a major railroad strike has been settled, but immovable mine owners and steel executives continue to face equally immovable miners and steel workers. Mr. Lewis, just a little disturbed by growing "return to work" sentiment among his miners, threw out a trial balloon to rally the AFL in joining his union in financial aid to the steel workers who, he trumpets, are under "vast and barbaric attack . . . to decimate all unions." But things will have to get pretty desperate before such old enemies as Green, Murray and Lewis fraternize in a common war chest.

In Pittsburgh the feeling is that negotiation with Mr. Murray is rather academic until Mr. Lewis is satisfied. To many a steel man it seems as if young Mr. Ford sold the bridge, although his company's willingness to discuss pensions is not new. Ford concluded that non-contributory pensions were bound to come, conceded the principle and concentrated on striking the best bargain possible. The scheme goes

into effect next March and when pensions begin in April, car owners as well as coal users will begin to pay the price of old-age security. Steel users also will pay a price yet undetermined. The steel industry opposition to non-contributory pensions lies in its shrewd suspicion that the size of pension that could be paid for by 6¢ an hr would not satisfy the steel workers for long, if at all.

U. S. Steel has offered Mr. Murray 6¢ for pensions if the workers add an additional 3¢ to raise the pensions up near the $100 per month level. But Mr. Murray is driven to an intransigence usually associated with Mr. Lewis. On his left the fellow travelers are waiting to exploit any failure and on his right Mr. Reuther already has a spectacular victory to his credit. It is likely to be a long strike in steel unless Mr. Truman is forced to action or the companies' united front collapses or, all together, they can find some way to save Mr. Murray's face. About the best compromise would be for the companies to give the 6¢ now, set up the pension mechanism and extract from Mr. Murray an agreement covering a long period of time and involving some future token contribution from the worker.

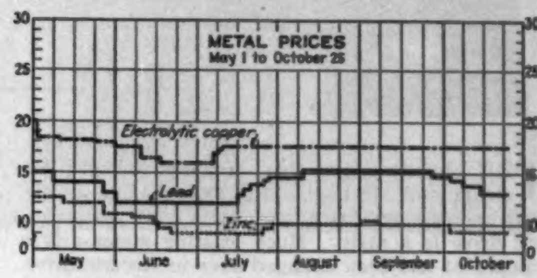
Mr. Truman can hardly be justified in seizure of the coal and steel establishments until the economy is seriously endangered, and such evidence is far less than scare-heads would indicate. Certainly the automobile industry, kingpin of industrial health, finds it difficult to sing the blues with any real conviction.

The record flood of automobiles which poured off Detroit assembly lines in August and September almost swamped many retail car dealers and a number of used car dealers quietly slipped under and drowned. There is no doubt that the sellers' market for automobiles is over, although the steel strike and retooling between now and Christmas may restore the balance between output and sales.

Base metal prices are in general on the weak side as a reflection of the steel strike and devaluation within the sterling bloc. Lead has dropped steadily to 13¢ a lb under the impact of falling consumption and increased foreign offerings. Zinc is down to 9.25¢. Large galvanizers are out of the market but demands from diecasters and brass mills are well maintained. Output from three smelters has declined, one because of a strike, and in general supplies of high-grade zinc are tight. Copper so far has resisted the downward trend and remains at 17.62½¢, while copper scrap even has shown a firmer tone. Brass and wire mills and appliance manufacturers have been buying for November delivery, and consumption is estimated as 30,000 tons per month in excess of production and imports.

Beyond the seas, the opportunities of devaluation are slowly bleeding away in England through a lack of forceful action to check inflation at home, to increase labor productivity or to check expenditures for social services in order to partly liberate the economy from its crushing burden of taxation. An increasingly large segment of the voting population is coming to the realization that the Labor Party is incapable of realistically meeting the economic challenge. The resentment is not that Labor is aiming for the social democratic welfare state but rather that the Party is jeopardizing the welfare state through sheer ineptitude. Western Berlin is now in such a state of collapse that it might well become the Achilles heel in the titanic West-East struggle for Germany. And in Japan business men are screaming in anguish as Prime Minister Yoshida applies the screws devised by the Detroit banker, Joseph M. Dodge, to get the Japanese economy off the American taxpayers' back by 1951.

A drama overshadowing all others, however, is rising to frightening crescendo in Yugoslavia. Only 12 years ago the Croat, Josip Broz, was purging the Jugoslav Communist Party of grave heresies then worrying the Comintern. His fondness for ordering people about earned him among his friends the nickname Tito. Now Marshal Tito has defied his old



masters and neighbors and turned toward his old comrades, while political trials in Hungary are being staged to prove that the bold heretic of Belgrade is, and always has been, nothing but a Fascist and an enemy of the Soviet Union.

Moscow must make an end to Tito, for he now publicly proclaims that Yugoslavia is leading a worldwide crusade to free the communist countries from Russian slavery. He has just asked his army to die, if need be, for the "working class of the whole world" and declared they are fighting "for a cause which has tremendous and incalculable importance . . . even if we fall . . . things have gone beyond our frontier and will grow . . . the truth blazes." Even the Russian Communist Party itself is now a target for Tito's splitting tactics.

Moscow is beginning to pick off International Brigaders (Spanish Civil War). Rajk (executed in Hungary) was one, and others will soon go down. Tito was the main recruiting agent of the International Brigade in Paris. He and the Brigade members mixed with Trotskyites who also fought against Franco, and the ex-Brigade members are inclined to stick together inside the communist parties.

There will soon be worldwide communist "peace demonstrations" to coincide with the initial military moves against Tito. An attempt will be made to have a few units of the Yugoslav army revolt, to be joined by a new International Brigade fighting under the slogan of "proletarian internationalism" and "defense of the people's democracies against an imperialist-Titoist plot."

In Washington the decision has been made to give Tito "all aid short of war." Power politics being the cynical chess game it is, the battered Greeks soon may be hustling pack trains of American armaments over their bloodied mountains to the country responsible for so many Greek widows.

Modern Electric Mine Hoists

by Russell S. Sage

THE electric motor has steadily replaced the steam and air engine for use in mine hoists, until today a new installation with other than electric drive is a rarity. Much existing steam-driven equipment has been changed over to electric drive. Driving power has grown in capacity since the initial electric unit rated 10 hp installed at Aspen, Colorado, in 1888, to 3000 hp and 4000 hp in the United States, and to 5500 hp in Canada—the largest in the Western Hemisphere. Electric installations now total in the thousands of units, a growth largely made possible by the development of large central electric-power stations and the extension of electric-power service to more mining areas.

Types of Winding Drums—The prevailing type for deep metal mines is the simple cylindrical drum, either single or double; if double, one or both have clutches if several levels must be frequently served. This type is also largely used for coal hoists, but the best performance for fast-operating cycles is provided by the double cylindroconical drum. This reduces the size of the motor and affords the greatest economy in power consumption. Simple conical drums have generally been replaced by the cylindroconical type. Reels seldom are used for new installations for, while effective in reducing the motor capacity and operating at high efficiency on certain cycles, the cost and maintenance of flat rope places them at a serious disadvantage. Koepe pulleys, so popular in Europe, have not found acceptance in America. Winding on rope in one layer has many advocates in order to obtain great rope life, but most deep hoists continue to use multiple layers. A notable installation at the Homestake Mining Co., Lead, So. Dak., employs double-clutched cylindroconical drums, 12 ft to 25 ft in diameter, upon which 5400 ft of 1⅞-in. steel cable is wound in one layer.

Winding drums generally employ fabricated steel plate construction which reduces the weight and eliminates cracking. Castings have given way to welded rolled-steel plate for lightness and greater strength. Recent equipments have used roller bearings throughout. For most cases, flexible couplings continue to be used between the motor and the pinion shaft, but there are notable examples of the use of the solid-flanged type. There appears to be a tendency to use higher "ratio of drum to rope" diameters, thus minimizing rope stresses due to bending around the drum.

To obtain optimum conditions for electric drive, efforts are being made to hoist in larger skips and to limit rope speeds to the order of 2500 fpm. However, high tonnages necessitate large skip loads as well as high rope speeds.

Drive Transmission—Gear drive is used for the majority of hoists, even for large capacities, and is obligatory when a-c motors are used. The trend away from drives by direct-coupled, d-c motors is indicated by the fact that during the past decade only three or four of this type have been supplied. One of these is a 1250-hp, 84-rpm, high-speed coal hoist with twin cylindroconical drums; one is a 2250-hp, 60-rpm copper-ore hoist, and two are each rated 1000 hp, 120 rpm, also in copper mine service. A 3000 hp, 60 rpm equipment is being constructed which will drive a double cylindrical drum deep-shaft hoist. For these slow-speed motors, the drive-half coupling is incorporated integral with the motor armature spider, and is bolted to a similar half coupling forged integral with the drum shaft. This positive type of drive obviates keying the motor armature to its shaft and eliminates its outboard bearing, the commutator end of the armature being supported by a simple stub shaft. Usually, the additional cost of a slow-speed motor for direct drive is greater than the cost of gearing; the over-all efficiency is approximately the same but, of course, the entire installation is simplified and gear noise and maintenance are eliminated.

Mr. Sage is employed as an engineer with the mining division, General Electric Co., Schnectady, N. Y., and is a Member of AIME.

Clutches and Brakes—In the newer hoists the multiple-tooth type clutch is frequently used, although the axial plate friction design, popular for many years, continues to be offered. The former appears to be of somewhat simpler and more sturdy

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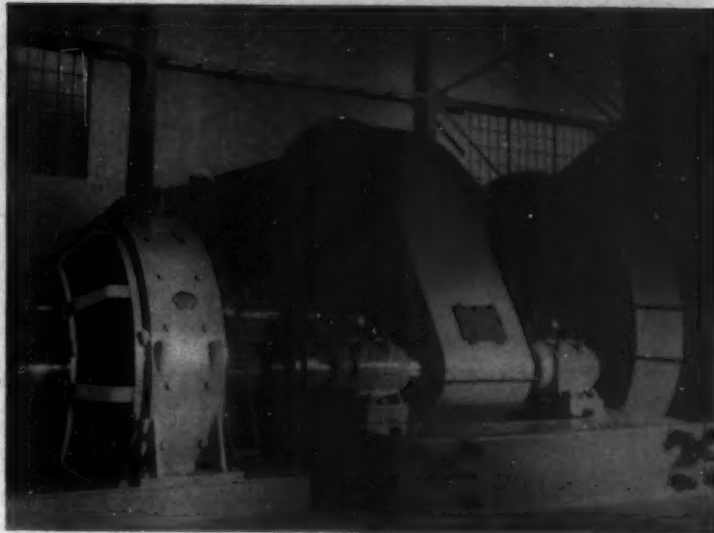
This is a lucid discussion of a-c versus d-c systems, completely automatic hoists, console-type operating controls and other improved features. Modern improvements are typified by Homestake's double drum ore hoist (right) with two 1500 hp, 300 rpm, 600 volt d-c motors.



design, is positive, and probably requires less maintenance, but it cannot be engaged as quickly nor with as great precision as the friction-plate type. Both types are operated by the same design of hydraulic or air control mechanism.

Most modern hoists are equipped with parallel motion post brakes arranged to be applied by a dead weight and released by hydraulic or air actuated thrust cylinders; oil under pressure is the most commonly used. Band brakes are still used, chiefly on small and medium capacity equipments. Auxiliary brakes occasionally are used working on a wheel mounted on the pinion shaft, thus providing dual braking means and absorbing the motor inertia independently. In some localities two braking systems are mandatory by law. All service brakes are arranged with an electric tripping means, whereby they may be automatically applied under certain emergency conditions. Oil pressure for the operation of brakes and clutches is usually supplied by a pressure-tank type of accumulator, which generally has supplanted the other gravity type. A regulator maintains pressure by starting and stopping the motor-driven pump.

The last few years have seen the development of the console-type of operator's control desk. Upon this are mounted all control levers—controller, brake, clutch, and safety devices—as well as electric auxiliary switches and push buttons; also electric instruments, pressure gauges, signal bells, etc. In a recent design, a new depth indicator with small clock-size dials has also been mounted on the console. The desk design is such that the operator is seated during hoist operation with all controls within arm's reach.

Dual Motor Drive—In recent years, the use of dual motor drive has increased, chiefly for hoists in the higher capacities. In this arrangement, two drive pinions are meshed at diametrically opposite points on the main drum gear and a motor is coupled to each pinion shaft. The chief advantage is the ability to use gears of half the width of a hoist employing a single motor of double capacity, which reduces the cost of the gearing and makes for better gear life and lower maintenance. A second, but doubtful, advantage is the possibility of operating at reduced capacity should failure develop in one of the motors or its control. One installation in this country utilizes two direct connected motors, one at each end of the hoist drum.

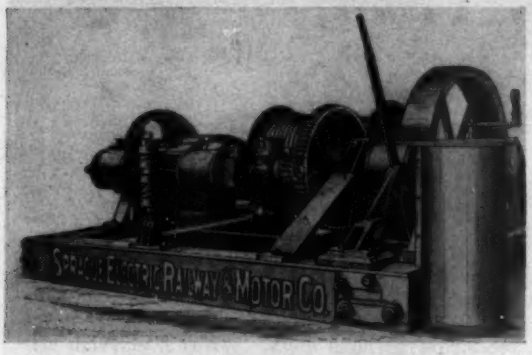
Numerous installations have been made ranging up to 3000 hp, and a 5500-hp drive with two 2750-hp duplicate motors is now under construction. This system of drive has been adopted for several small outfits, at least one being rated 300 hp, utilizing two 150-hp motors.

Dual drive has been adopted for some underground installations because of more advantageous space requirements, or where the maximum operating conditions will not be encountered for a number of years. The initial installation, therefore, was limited to a single motor, the second one to be conveniently added at some future time. Companies which have these geared dual drive installations are as follows:

Homestake Mining Co., (two 1500-hp motors); Cleveland Cliffs Iron Co. (two 1500-hp motors); Bunker Hill & Sullivan Mining and Concentrating Co. (two 600-hp motors); Miami Copper Co. (two 1400-hp motors); Potash Co. of America (two 500-hp motors); New Jersey Zinc Co. (two 450-hp motors).

A-c Motor Drive Prevalent—American manufacturers have supplied more than 1500 electric mine hoist equipments aggregating some 900,000 hp, of which approximately 85 percent are of the wound rotor induction motor type, the remainder being d-c motor driven. The minimum size included in this estimate is 200 hp; there are numerous addi-

tional installations in smaller capacities. In the United States the largest installation is a 4000-hp d-c motor driven coal hoist. Next in size are three 3500-hp a-c drives serving long slope iron ore hoists. These are followed by four d-c installations each of 3000-hp capacity, two hoisting gold ore and two iron ore in deep vertical shafts. It is interesting to note that a large southern states utility supplies power not only to the above mentioned 3500-hp a-c hoists, but four others—two of 2500-hp and



A 10-hp hoist installed at Aspen, Col., in 1889, which is believed to be the first motor-driven mine hoist to see service in the U. S.

two of 1800-hp capacity. All of these hoists are operated by the same mining company. The popularity of the a-c hoist drive system is further pointed up by the fact that a coal company and an iron ore company each operate sixteen 400-hp duplicate equipments.

For all except the smaller sizes, control equipment with magnetic switches, grid resistors, and definite time relays or current relays, or both, are used. Such control affords so-called automatic acceleration and protects the entire equipment against abusive handling. Liquid rheostats, once quite prevalent in this service, have virtually disappeared and none have been supplied for several years.

Dynamic Braking—Use of the dynamic braking feature for induction motor-driven hoists has increased. This involves adding to the conventional magnetic contactor control means for applying direct current to the motor stator windings, thereby permitting the motor to become a generator and thus function as an electric brake when lowering overhauling down-going loads. Normal loads being hoisted can also be brought nearly to rest by this scheme of control. Used principally on single-track slope hoists, it is becoming more popular with operators for shaft hoists as well, particularly for unbalanced hoists. With d-c dynamic braking, loads may be lowered at partial speeds with no expenditure of energy from the power supply other than the insignificant amount of excitation power. The conventional control system limits the lowering speed to full speed, unless plugging (motor counter-torque by motor reversal) is resorted to or the mechanical brakes utilized. The plugging method is wasteful of electric power and rough on the equipment. Dynamic braking control has been applied to nearly 100 mine hoist equipments in the United States, one of the earliest on record being in 1913. Capacities have ranged from 125 hp to 3600 hp. Three duplicate equipments of the latter capacity serve long single-track slope iron-ore hoists whose rated hoisting speeds are 3600 to 4000 fpm. With the dynamic braking controller, an empty skip or a man load may be lowered at any fraction of full hoisting speed, and electric braking is available to assist in coming to rest, thus relieving the mechanical brakes of the bulk of the braking duty.

The operator is generally provided with two controllers—one for normal motoring, the other for dynamic braking. Recently, however, an equipment was supplied with but one operating lever. This was arranged in the well-known "H" manner.

Motor Drive Systems—By d-c motor drive is meant a motor whose speed and rotation are controlled by adjusting the polarity and value of the voltage applied to its armature—i.e., by the Ward-Leonard system. In this system a separate generator is utilized, practically always driven by an a-c motor, either of the synchronous or induction type. Control is afforded by varying the current in the generator fields through a master controller. The distinguishing features of the Ward-Leonard system are: (1) the comparative independence of the hoist motor speed of the value of the motor load on all points of the controller; and (2) the ability to obtain dynamic braking by merely returning the controller operating handle toward its "off" position.

Development hoist, powered by a 60-hp motor, operating in a Tennessee zinc mine.

Regenerative braking current is thus provided without moving the controller through the neutral position and the opening and reclosing of any circuit device is avoided as is necessary with the induction motor system when plugging to stop. Regenerative braking permits convenient and efficient lowering of overhauling loads at full or fractional speed. These two exclusive features place the d-c hoist in first place as far as excellence of control and safety in handling are concerned. D-c motor drive is generally the choice for large high-speed shaft mine hoists; and is considered the only practicable system for fast shallow coal mine hoists, especially where a large braking effort is required to bring the cage to rest in the allotted time. The cost of the d-c system, however, is in the order of two and a half to three times that of the simple

induction-motor type. For some hoisting its efficiency may justify its higher cost, but usually other considerations indicate its desirability.

The latest improvement in control for d-c hoists is the use of indirect excitation. This involves a separate exciter of special design to energize the main hoist generator fields, the operator's controller handling only the minute field current of the exciter. This system, in one form, uses an amplidyne exciter, a machine characterized by its high amplification ratio and its speed of response. Its use eliminates many of the usual generator field contactors and accelerating and retarding relays, but at the same time affords positive control of the accelerating and retarding currents and improved speed regulation. Most d-c drives installed since 1941 employ the amplidyne control system.

Load Limiting Systems—A distinct advantage of d-c drive is the possibility of relieving the power supply of heavy load demands when the hoist is being accelerated to full speed each trip. For large capacity hoists, only the largest systems can cope with the heavy current demands from the induction motor drive without overloading the generating station. With the d-c system these heavy fluctuating power demands may be ironed out by adding a flywheel and automatic load limiting rheostat to the Ward-Leonard m-g set and control system. This system, however, is to be avoided wherever possible because of its additional cost and low efficiency as compared with other systems.

It has been found that load conditions can be handled by means of a synchronous motor-driven m-g set without undue disturbance to the power system. This is accomplished by an automatic field regulating means, whereby the current drawn by the synchronous motor is so regulated that harmful voltage drops during hoist operation are obviated. Careful studies of the calculated load diagrams with respect to their effect on the power system are necessary. In several instances such a study has changed the purchaser's intention to install the flywheel system in favor of the more efficient and lower cost synchronous motor system.

Automatic Mine Hoists—Automatic mine hoists frequently have been considered with the object of realizing greater hoisting efficiency and for the elimination of a full-time operator. A number of these have been in operation for many years. In 1915 the Inspiration Copper Co. installed two 580-hp main ore hoists which have been operating ever since without regular operators. In 1924 the same company installed a similar type drive rated 2150 hp at its porphyry hoist and this is still in daily operation. In 1928 the Miami Copper Co. installed a similar type of control for its 2800-hp main ore shaft hoist. This likewise is in regular operation without hoist operators. In all of these, the hoist is started by the skip loader at the underground ore pocket by merely pushing a starting button. This causes the brakes to be released, the controller is turned "on" by a small pilot motor, the hoist accelerates and continues to run at full speed until the dump is approached, at which time it slows down and finally stops after the skip has dumped its load. In a few seconds the skip in the opposite compartment is loaded and sent up the shaft in a similar manner. Slowdown is attained by means of a cam geared to the hoist drum so that the operation simulates a mechanical arm. Where large tonnages are handled and hoisting can be carried out uniformly for long periods, such automatic operation holds possibilities of real benefits.

Potash Co. of America's double-drum ore hoist, with dual control from two 500-hp, 575 rpm, 325-volt d-c motors, in operation at Carlsbad, New Mexico.

The latest example of automatic ore hoisting is in the Potash Co. of America's mine near Carlsbad, N. M. It consists of a 1000-hp d-c drive for hoisting 16,000 lb of potash ore per trip from a depth of 1150 ft at a rope speed of 1500 fpm. This system includes an amplidyne exciter for the 750-kw hoist generator, and the automatic functions are accomplished by simpler and cheaper apparatus which also provides essential protective and safety features. This is in line with manufacturers' efforts to develop improved methods in the application of industrial electric drive and control systems. In this particular case the purchaser preferred to initiate the successive starts of the hoist by means of a time switch so adjusted as to cover the time taken to dump and reload the skips. Any of the several methods of initiating the start may be employed as desired by simple changes in the control circuits. All automatic mine hoists can be handled by a regular operator, this being accomplished by merely throwing a selector switch.

The most favorable conditions for automatic hoisting are at those mines having but one or only few operating levels, high tonnages, moderate rope speeds, adequate head room, and uniform loads. The d-c system is definitely indicated for this application. Both theory and practical experience have demonstrated that the induction motor system is not suited to automatic hoisting except where the rope speed is less than approximately 400 to 500 fpm, and even for such cases a dual motor drive is necessary, usually combining wound rotor and squirrel cage motors or employing a two-speed wound rotor motor.

Auxiliary Equipment for Truck-Haulage Pits

by Charles A. Lindberg

Mobile cranes on tires are perhaps the most important accessory in truck-haulage pits. They usually are of 20-ton capacity at short radius and with outriggers but have considerable overload capacity. Standard booms are 30 ft but have 10-ft extensions with which they are usually operated.

Cranes have two engines, both originally gasoline, but 150-hp Diesel engines have been found more reliable for the propulsion motor, the 100-hp gasoline motors being retained for hoisting. Provisions are made for dropping the ballast counterweight to reduce axle weights to legal limits for highway travel. The weights are carried on a regular truck or are transported on an extra trailer axle behind the crane.

This is the second of three parts of a paper given by Mr. Lindberg, Oliver Iron Mining Co., before the University of Minnesota Annual Symposium.

Tractors—Probably equalling the cranes in usefulness are the track-laying tractors which are used to prepare roads and other surfaces, to clean up at the shovel, and for dozing on stripping dumps. A new type of tractor mounted on rubber tires has been tried out on the Mesabi Range for the past year and a half. The advantage of this design is its mobility which makes it capable of taking care of the spill at the shovel and then running to the dump to clean up. Alternating between these two jobs, it relieves heavy tractors that can be used to better advantage on heavier work that does not require so much traveling. This tractor can travel at speeds of 12 to 13 mph and is designed to facilitate repair of the expendable parts. Weaknesses have developed in the internal construction which have seriously marred the performance record of this unit, but when used within its capacity it is quite successful.

Graders—Since good roads are the first requisite of a successful truck-haulage operation, graders are indispensable. They are frequently supplied with a front blade used for all kinds of dozing jobs, some too heavy for the machine. Graders range in weight from 9 to 12 tons with the trend toward heavier machines.

One popular machine drives and steers on all four wheels with hydraulic controls. The blade is about 12 ft long and can be angled to either side or tilted for bank work. Snow plow attachments are also available for winter use. Other designs feature tandem rear drive and front-wheel steering. Power steering is common although one model used is entirely manual. These designs have angle and tilt blade control and can be fitted with front dozer blades.

All graders on the Range are Diesel powered. Two makes include special gasoline starting accessories in the engine. Because of the severe service and great exposure to tire hazards, tire life on graders is short. Two of the leading tire manufacturers have recently developed improved grader tires combining heavier carcasses with low pressures, and having treads with great traction and extra resistance to impact and cutting.

Sprinklers—A large quantity of water is required in haulage pits for road sprinkling in the summer, for drill rigs the year round, and for miscellaneous uses. Stock models of sprinkler trucks with tanks of 1000-gal capacity were first used for these jobs. Their performance was not very successful or economical in pit work principally because they carried 4-ton loads on one-ton chassis.

To improve this situation a number of operators have mounted 2500 to 4000-gal tanks on heavy-duty truck chassis that have been retired from ore haulage. These units have also been equipped with small air-cooled, gas-engine pumps to put pressure on the sprinklers which increases the coverage at each pass and permits faster traveling speed while sprinkling. The pumps also provide pressure to elevate water to drill rigs on banks.

Fueling trucks—Although a majority of operations receive their fuel oil supply through oil companies who make deliveries to all points of the operation where fuel is used or dispensed, the larger operations receive their fuel in tank cars and store it at a central point. For distribution to the pits and scattered users of fuel oil, tank trucks of 1000 to 2000-gal capacity are provided. These trucks have adequate chassis capacity for the loads carried and include pressure pumps driven from power take-offs on the transmissions, fluid meters to measure deliveries, and reel mounted dispensing hose about 75 ft long. It has been found advisable to add filtering equipment to filter all oil delivered because of increased contamination in present-day fuels.

With the increase in tonnages of stripping and ore being handled in open-pit mining, reaching a ratio of 5 to 1 in some Iron Range operations, the problem of materials handling has become critical. Although mechanization has been the answer, make-ready and maintenance can be the difference between profit and loss. Herein is described the equipment that keeps the ore moving in truck operations.

Specifications of the larger trucks should allow for proper weight distribution to give legal axle weights for highway operation.

Mobile greasing units—Large all-year operations have service garages that provide for repair work and servicing of trucks including fueling, greasing, air for tires, and gear lubricants for transmissions and rear axles. For contract jobs and isolated operations which are worked during the summer months only, these servicing facilities are provided by so-called "luber" units. A compressor and an assortment of tanks for storage of lubricants and air operated dispensing equipment are mounted on a special truck which goes to equipment on the job. This service is a daily and important job in a well-maintained operation.

Portable welding generator—Today we are dependent on welding facilities in our operations to an extent that makes us wonder how we ever got along before we had them. There are two methods in general use, gas and arc-welding, with arc-welding far in the lead.

Wherever suitable power is available the motor-generator type of welding machine is used, but for other arc-welding work, a truck-mounted gas-engine welding generator is used. Accessory equipment includes provision for carrying gas welding and cutting equipment, electrode storage and illuminating spotlight into the field. These units can go almost anywhere and are capable of doing the highest class of welding work. Engines are popular automobile engines with special governor mechanisms that are easy to service and repair.

Floodlights—For night illumination of pits and dumps where electric power is not available for floodlighting, portable floodlighting units are used which mount an air-cooled gasoline engine with a direct-drive 5-kw, 110-v a-c generator. Four 1000 watt floodlights with non-glare lenses are mounted on posts on the four corners of the machine and can be elevated, revolved, and tilted to throw the light wherever needed. Plug-in connections for extension lamps or portable tools are also provided. An electric starter and simple-control rheostats are included. The unit is covered and mounts on two rubber-tired wheels and has a tow bar with a drop-leg for support. The unit weighs 1800 lb.

Mobile power unit—An interesting unit made up in our shops for use at our Hibbing operations is a 145-kw, 250-v d-c generator driven by a 200-hp Diesel engine, the assembly being mounted on a heavy-duty, six-wheel truck. This mobile power unit can be connected by electric cable to a shovel, and provides power to travel the shovel for long distances without transporting and trailing long lengths of power cable. With contemplated increased engine power, it would be capable of supplying enough current to permit shovel operation in isolated locations where no power is available or where the extent of the work would not justify running in a power line.

Trucks, trailers, and semitrailers—To complete our summary, the equipment that makes possible the movement of the tremendous tonnages of supplies, repair parts, machinery, and equipment which are a necessary part of mine operations should be mentioned. This includes trucks ranging from ¼ to 5-ton capacity, in several makes, which are used for hauling men and supplies. A few trailers designed to be towed behind standard trucks and having capacities up to 20 tons are also used.

We also have trucks mounting hydraulic, short-boom cranes for lifting, loading, and repair work where the weights handled range up to 5 tons, and supply trucks with power-operated tail gates which are convenient for loading and hauling heavy and bulky items weighing up to a ton.

The principal transport medium for the movement of drills, tractors, small shovels, and heavy machinery are semitrailers having tandem rear-axle tractors of 5 to 7-ton capacity, a fifth wheel, and tandem rear-axle trailers. These will range in capacity up to 30 tons but will be limited as to load by highway limits on axle loadings. To conform to present-day practice, tandem axles should be spaced not less than 40 in. Highway limits are 8 ft for width, 45 ft for length, and 12 ft for height. If loads exceed 18,000 lb per axle, special permits are required on state highways.

Salt-Bath Hardening Increases Churn-Drill Bit Life

by Carrol A. Quam

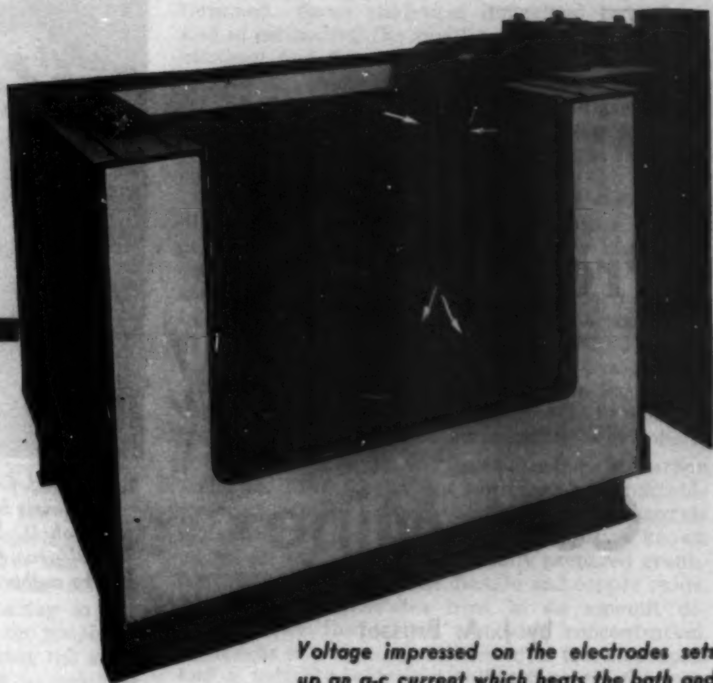
DURING the first years of operation of the titanium and iron mine of the National Lead Co. at Tahawus, New York, efforts to increase production were hampered by the increased load put on the facilities for sharpening churn-drill bits. The ore and rock are extremely hard and abrasive and it was necessary to sharpen and harden a large number of bits per day to keep the churn drills supplied. Efforts to increase the capacity of the bit shop by a two-shift operation were not wholly successful in that it was hard to train men to do a satisfactory job of sharpeinng and tempering the bits. The number of bits that were improperly tempered increased, thus boosting the daily requirements for bits at the drills and increasing the load on the bit-sharpening facilities.

Mr. Quam is assistant mine superintendent at the MacIntyre Development of the Titanium Division of National Lead Co., Tahawus, N. Y. He is a member of AIME.

In all tempering and hardening of steel heated in oil-fired furnaces, consistent results depend to a large extent on the human element. Color of the steel is the usual method of determining the temperature, and this factor is influenced by such conditions as time of day, weather conditions, and the physical condition of the man heat-treating the steel. The hardening operations on the 9-in. churn-drill bits used in blasthole drilling at Tahawus were no exception. Some of the bits would have a well tempered face, while others would be too hard and crack, and still others would be too soft and mushroom.

In changing the hardening operation from an art to a science by the use of an electric salt-bath furnace, it is possible to achieve a consistent uniform hardness in all the steel. This can be done by using a heating medium, the temperature of which can be controlled to a very limited tolerance. In all furnaces where hot gases are the media for transmitting the heat to the steel, there is a tendency to heat the steel too far up the bit. A liquid is much better medium for transmitting and controlling the heat. The electric salt furnace can be used to make a science of the churn-drill bit-hardening operation.

Molten salt, heated by a series of electrodes, is the medium used to transmit the heat to the bits. The temperature of the bath is controlled by means of a thermostat to plus or minus 5F of the desired temperature. A recording potentiometer indicates when the steel has reached the desired tempera-



Voltage impressed on the electrodes sets up an a-c current which heats the bath and creates natural circulation as illustrated in the Ajax salt-bath furnace. Melting point of bath is between 200 and 600 F.

ture, and also how long the temperature has been maintained. This eliminates any guesswork on the part of the operator.

Before the installation of the electric salt-bath hardening furnace at Tahawus, the average footage drilled per churn-drill bit used was 4.42 ft. After the electric salt-bath furnace had been put in operation the footage increased to 6.79 ft per bit under similar drilling conditions. The drilling speed increased 12 percent and, as the bits were of uniform hardness, there was less trimming necessary, resulting in considerable additional life to each bit.

The salt bath furnace in use at Tahawus has a temperature range from 1300F to 1650F, will heat four 9-in. churn-drill bits simultaneously, and has a capacity of 8 bits an hour. The cost of operating the salt-bath furnace is less than the cost of operating the oil-fired furnace previously in use.

After the bits are forged they are placed on a rack to cool to 800F. They are the npicked up by an electric chain hoist mounted on a self-supporting jib crane and transferred to one of the four stationary chain hoists which are suspended over the salt-bath furnace. The bits are lowered until the cutting edge is approximately 1½ inches into the molten salt. This heats the cutting edge to the proper temperature for quenching and also minimizes the extent to which the heat travels up the bit. After the bit comes up to heat it is held in the furnace for 15 minutes, at the end of which period it is removed from the furnace with the electric chain hoist and immediately quenched. The bits are supported upright in the quenching tank with only 2 inches of the cutting edge submerged in the water.

The manufacturing industry has used the electric salt-bath furnace for quite some time in precision hardening of tools, gears, shafting, etc., but it has not been utilized to any large extent by the mining industry. As the heating medium is a molten liquid, air is excluded from the heating bit. This tends to reduce the loss of carbon from the steel. Similar furnaces with a heat range between 1800 and 2400F should, in the near future, find increased application in heating the churn-drill bits prior to the forging operation. Thus, the steel would be worked at the proper temperature and the loss of carbon in the steel would be reduced to a minimum.

The application of the salt-bath furnace for the heating of churn-drill bits in the hardening operations was first brought to our attention by the Jones and Laughlin Steel Co. The results obtained from their installation at Benson mine, Star Lake, New York, convinced the National Lead Co. of the advantages of this type of furnace.

The author wishes to thank the National Lead Company for permission to publish this article.

Diesel Proves Safe in Coal Mine

British and Canadian coal mines have successfully used Diesels for haulage in underground coal mines, although U. S. regulations still prohibit their use. This 9½-ton Hunslet engine is the one referred to by the author.

by J. A. Brusset

THE Adanac mine was opened by West Canadian Collieries, Ltd. in 1943, and the question soon arose as to which system of haulage should be selected. Compressed-air locomotives and ropes were rejected on the ground of high cost. Since under the Alberta Mines Act the use of trolley locomotives underground in coal seams is not permitted, the choice lay between storage battery and Diesel locomotives, The preference of the author, who had experience with both in gassy French coal mines prior to 1930, was for Diesel locomotives due to lower cost of installation and greater flexibility and reliability.

It was realized that the adoption of Diesels would be somewhat of an innovation since in the United States the mining laws prohibit their use underground in coal mines, and in Great Britain in 1943 their use was only in the incipient stage. By 1945, 25 Diesel locomotives were in use underground in gassy mines in Great Britain, and approval had been granted for the use of an additional fifty of two approved types also for gassy mines.

Numerous special regulations of the British Coal Mines Act have been formulated to govern the use of Diesel locomotives. For instance, they are not allowed closer than 200 yards from the working face; daily inspections are required; and a weekly checkup and cleaning must be given the engine by a competent engineer. Also, methane content of the air in the roadway can never exceed 1.25 percent, and daily checks must be made if it exceeds 0.75 percent.

Under Alberta regulations, we were required to use a flameproof type engine, to be used only in fresh air intake. The engine fumes had to travel along a separate ventilation split where no man was permanently employed. It is forbidden to run a Diesel locomotive into an unventilated road. A sample of the exhaust gases must be analyzed at least once every three months, and the engine is deemed defective if the gases contain more than five parts per thousand of carbon monoxide. The oil used as fuel must not have a flash point below 150F.

A Hunslet Mark II 50-hp flameproof Diesel locomotive was delivered to the Adanac mine in July of 1947. It was put into operation the following month after several weeks of testing and training the personnel on a track outside the mine, and the first underground tests were then conducted by government inspectors.

Mr. Brusset is an AIME member and vice president of West Canadian Collieries, Ltd.

The Hunslet Mark II weighs 9½ tons, is 5 ft 3 in. high, 4 ft 6 in. wide, and 14 ft 6 in. long. It has a 4 ft 3 in. wheelbase. The Gardner Diesel engine is four-cycle, four-cylinder, and adjusted for an altitude of 4000 ft, giving 50 Bhp at 1300 rpm. It reaches a top speed of 9 mph.

Various safety devices are included. On the air intake side, the air passes first through an oil bath air cleaner, then through a stainless steel spark arrester. On the exhaust side, the gases of combustion first go through a gas conditioner of all-welded stainless steel construction where they are cooled by water, then through a stainless steel flame arrester. All joints are flameproofed against any possibility of internal explosion. All electrical gear (headlights especially) is totally enclosed and flashproof. (See Fig. 2.)

A fuel oil having a flash point above 170F is used, to which is added two quarts of lubricating oil (light type) per 100 gallons of fuel oil, in order to

lubricate the fuel injection pumps. Specific gravity is 0.85 at 60F; and Btu is more than 19,000 per pound.

Referring to Fig. 1, it will be seen that the pitch of the seam varies from about twelve degrees at the water level to 25 degrees at the outcrop. This leads to two different types of equipment, a Joy-loader being used to drive the main entry and water level, and duckbills to block out and extract the pillars. The seam is about 10 ft thick. A cap rock, varying in thickness from one to two ft, overlays the coal and has to be held close by timbering and logging.

For one year, from August 1947 to August 1948, the use of the locomotive was allowed only in the portion A B of the entry; at that time, the ventilation was as shown in Fig. 1, with two doors at B diverting the air to raise No. 24 leading to the fan on the outcrop of the seam. Thus, the desired separate air split for the locomotive was created, which worked on fresh air derived either from the entry A B or from the water level C D. The combustion fumes traveled directly up raise No. 24 and along part A B of the entry, where no man is permanently employed. The rest of the active workings of the mine were ventilated through raise No. 25 (adjacent to and south of No. 24) leading to the same fan. The fan is an exhaust fan of the propeller type, and the volume of fresh air entering the mine at A and circulating in the entry up to point B was about 30,000 cfm. Measurements showed 72,000 cfm entering the fan.

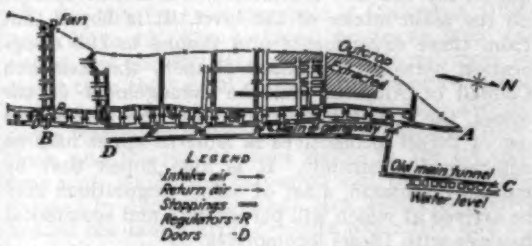


Fig. 1—Map of workings at Adanac.

The entry has been driven on a grade of 0.5 percent in favor of the load and is timbered with sets spaced 5 ft apart, the clear space inside timbers being 8 ft in height by 14 ft in width. The tracks have been arranged so that the cars can be handled by the locomotives in trips of twenty. Each car receives three tons of coal. Tests have shown that the locomotive could handle fifty cars at a time, or a net load of 150 tons of coal.

The length of the haul then averaged only one third of a mile. With the short haul and small tonnage (about 350 tons per day), the locomotive was loaded to scarcely more than 15 to 20 percent of its capacity. Under these conditions the tests, as run, could not give any final indication of the cost of haulage per ton-mile, but they demonstrated the safety of the operation.

The toxic constituents of exhaust gases from Diesel locomotives are carbon monoxide, oxides of nitrogen, oxides of sulphur, and aldehyde vapors. Of these, carbon monoxide is most readily determined. Some analytical difficulties have been met in estimating the small quantities of oxides of nitrogen and the low concentration of aldehydes present in Diesel exhaust gases. The latter is best related to its odor and to the eye and nasal irritation caused by it. Under normal ventilation conditions, and using a fuel oil of the specified sulphur content, the concentrations of oxides of sulphur are not significant from a toxic point of view. Series of determinations of the carbon monoxide content of the exhaust gases and of the mine air in the vicinity of the locomotive were carried out over separate working periods by members of the staff of the Research Council of Alberta. Direct access to the surface of the flame arrester fitted to the exhaust gas conditioner of the engine was possible through a rectangular opening in the locomotive cowling, so that the exhaust gases could be sampled before diffusing into the surrounding atmosphere.

Determinations of the concentration of carbon monoxide were carried out by means of a portable indicator. In this apparatus, the carbon monoxide is oxidized to carbon dioxide over a catalyst known as "hopcalite," which is a specially prepared granular mixture of manganese dioxide and copper oxide. The oxidation liberates heat in an amount determined by the carbon monoxide concentration. By means of a system of differential thermocouples and a suitably-calibrated millivoltmeter, the percentage by volume of carbon monoxide can be read directly on the millivoltmeter scale. It is claimed that a concentration of 0.005 percent of carbon monoxide by volume can readily be estimated and that readings can be approximated to 0.001 percent. It is, however, questionable whether readings of the accuracy of 0.002 percent can be obtained at the zero end of the scale of the indicator. The actual instrument employed was calibrated shortly before use, employing air of known carbon monoxide content.

These two tests showed that conditions were satisfactory in the entry. According to the U. S. Bureau of Mines, a proportion of carbon monoxide not exceeding 0.01 percent by volume is permissible, and at Adanac it is apparently much lower than

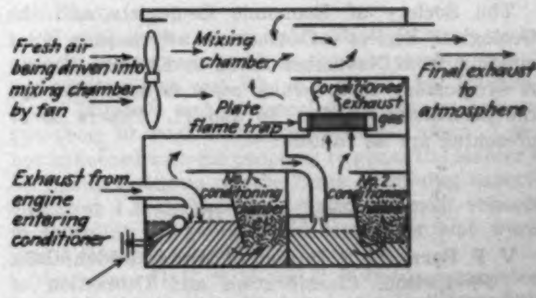


Fig. 2—Gas conditioning and flame-arresting device on the Hunslet Mark II engine.

that. In the Research Council's report, it is stated that 0.01 percent of carbon monoxide by volume is the maximum allowable in mine air where men may work for a prolonged period. The percentage of

carbon monoxide in the exhaust gases is about four times as great (0.06 percent) when the locomotive is idling than when it is running (0.015 percent). No tests were made for nitrogen oxides as in the very minute amount actually present they are not easily detectable. Aldehydes were also apparently negligible—at least the aldehyde odor was barely perceptible in the mine air.

A further test was carried out on December 2 under conditions of ventilation practically identical with those in the August tests. The results show no appreciable change in the behavior of the locomotive after three and one-half months of steady operation, and the proportion of toxic gases had remained low.

During the summer of 1948, further tests were carried out. On idle days when no men were working in the mine, the doors at B were thrown open, and the ventilation rearranged so that the whole entry became an air intake from A to E, while the counter was used as a return for the air sweeping the entry and carrying the combustion fumes of the locomotive. It was found that under these conditions, the volume of air traveling along the entry from A to B was increased to about 50,000 cfm and that the ventilation at E was much improved. With the locomotive idling at any point between A and E, no carbon monoxide was detectable at E nor at any other point, nor was there any odor of engine fumes. This led us to asking the chief inspector for permission to use the locomotive without separate split; i.e., on the main air intake of the mine over the whole length of the entry. This permission was granted after an exhaustive series of tests by the mine inspector in August 1948, and the Diesel locomotive has since then operated under those conditions without giving rise to any complaints.

Safety underground with a Diesel locomotive depends upon attention to two groups of precautions: (1) Preventing a flame or explosion inside the engine from issuing into the outside atmosphere. (2) Preventing the engine from producing toxic gases in dangerous quantities.

Flame arresters and a gas conditioner take care of the first danger. The flame arrester on the exhaust side is changed before every shift, and the spare arrester is taken apart, washed, and brushed so as to be ready before the next shift. As to the prevention of formation of toxic gases, we apply the rules of British and continental practice, which simply means the engine must be kept in excellent mechanical condition at all times. So far, the expenses of upkeep have been low. For the first four and a half months of operation they amounted to only $151.40, most of which represented wages.

After more than a year of satisfactory operation at Adanac, we have asked for a permit to operate a Diesel locomotive under more normal conditions of haulage, which would make it possible to determine the cost of haulage per ton-mile. A permit has been granted for a larger locomotive to be operated on the No. 5 level of the Greenhill mine.

A steel-arched entry, fifteen feet wide and nine feet high, will be necessary. The mine will be ventilated by 60,000 cfm of air. The new locomotive will be used to haul loads for a mile and a half on a .005 grade. It will carry 150 tons of coal per trip, and a total of 800 tons a day. Its use should represent a considerable saving for the present endless-rope system.

It should be noted that due to the excellent ventilation in that entry no separate split will be required for the new locomotive, which will operate on the main intake of the level. It is hoped that from these experiments and thanks to the co-operation between the Mines Branch, the Research Council of Alberta, and the management of the mines, the conditions required for the permissible use of Diesel locomotives in Alberta mines may be determined accurately. It is also hoped that by mutual discussion, a set of safety regulations may be arrived at which will permit safe and economical haulage with Diesel locomotives.

SEG-GSA Joint Meeting in El Paso

The Society of Economic Geologists and the Geological Society of America will hold a joint meeting from November 10-12 in El Paso, Texas. A symposium on low-rank coals is scheduled for the afternoons of Nov. 10 and 11. Papers to be presented are as follows:

November 10

V. P. Parry, U. S. Bureau of Mines, Golden, Colo.
Production, Classification and Utilization of Western Coals.

R. P. Bryson, USGS.
Distribution Occurrence and Resources of Sub-Bituminous and Lignite in the Western United States.

B. F. MacKay, Geol. Survey, Ottawa, Canada.
Resources of Low-Rank Coals of Canada.

H. B. Stenzel, Bur. of Econ. Geology, Austin, Texas.
Coal Resources of Texas.

W. B. Roe, Truax-Traer Coal Co., Chicago.
Geological Features of North Dakota Lignite.

November 11

E. S. Barghoom, Biological Laboratories, Harvard Univ.
Geological and Botanical Study of Brandon Lignite and Its Significance in Coal Petrology.

B. C. Parks, U. S. Bureau of Mines, Pittsburgh.
Petrography of American Lignites.

R. M. Kosankc, Illinois State Geol. Survey.
Review of Coal Research 1948-49 (other than research studies).

Paul Averitt, USGS.
Present Status of Coal Resource Studies in the U. S.

E. H. Robie, Clyde Williams and J. W. Barker listening to AIME President L. E. Young address the Mid-Year Banquet at the Neil House in Columbus.

AIME Mid-Year Meeting

All Divisions of the Mining Branch participated in the Mid-Year meeting held at Columbus, Ohio, Sept. 25 to 29. The technical programs were excellent and the 522 who registered found more to digest than they could conveniently handle in three days of technical sessions. Hugo Johnson and his committees were thorough in their meeting preparations, and the results were visible in the smoothness with which things moved and the good time enjoyed by those attending. Mrs. Elmer R. Kaiser headed the ladies arrangements committee and acquitted herself charmingly and efficiently. The Ohio Valley Section is to be congratulated on this fine meeting.

Joseph W. Barker gave the principal address at the banquet, stressing the importance of research and the advantages of allotting research funds through numerous private foundations rather than one central government agency. Following the banquet, a film entitled "No Man Is an Island" was shown through the courtesy of the Consolidated Mining and Smelting Co. of Canada. It gave a dramatic and colorful portrayal of the mining, concentrating, smelting, and manufacturing processes of COMINCO which are made possible through the co-operative effort of the employees and management. R. R. McNaughton of that Company was on hand to answer questions.

Education

Professor A. C. Callen, Lehigh University, commented on the Mineral Industry Education Division sessions after the meeting. About the papers by J. W. Woomer and G. T. Harley on graduate courses for mining engineers, Professor Callen commented: "Mr. Woomer surprised me by taking an approach to the problem directly opposite to the one I expected. He took the stand that although industry needs men with graduate training, they do not have many positions for them to do the type of work needed in most of the mining companies. My own opinion is that two groups of men should take graduate courses—those who want to go into research, and those who have gone into industry to gain some practical experience and then feel that they need more specialized training to carry on with their work. This latter group includes prospective teachers. Both these groups should take graduate work. I think that the average fellow should be content with his B.S. degree and go into industry with that.

"My impression was that Mr. Harley doesn't know exactly where men with graduate training would find employment, but I have a hunch that International Minerals and Chemical Corp. knows how to put them to work doing constructive things. I am not in accord with his proposal to grant the Master's or Doctor's degree on the basis of mining experience, for I feel that the practice of most schools in awarding the professional degree for such work plus a thesis is sound."

Professors H. E. Nold and C. S. Crouse presented papers in which they discussed so-called "broadening courses" in mineral industry curricula. At Ohio State they have gone to a five-year program in order to include them, while at the University of Kentucky they have been included in the four-year program at the expense of certain specialized courses. Professor Callen's opinion on the value of these broadening courses?—"Can't say, and right

now, I don't think anybody else can either, as we have not had enough experience with graduates in whose programs such courses have been included. However, I think this trend is brought about by mature engineers projecting themselves back to their own college days and trying to figure what could have been done to help them with their careers. The result of this self-projection has brought about the idea of including a core of humanistic-social courses. It has also brought about a trend of deleting advanced specialty courses in order to introduce the humanistic-social courses. My own opinion is that the colleges are justified in this trend and I believe many mining executives feel the same way about it."

Mining Geology

At the Mining Geology session, a paper by R. E. Barnett on underwater seismic investigations for civil engineering studies proved interesting to the mining men present. J. R. Van Pelt, of Battelle, explained later: "Mr. Barnett was studying the depth of cap rock in the Ohio River from Pittsburgh to Louisville for a flood control project. The project would involve rebuilding dams and docks and, therefore, it was necessary to find the depth of cap rock which was usually about 9 to 12 ft below surface. The refraction technique was used, setting off about half a stick of powder at points along the channel of the river. The paper discussed the variations in normal seismic work created by working under water."


J. R. Van Pelt, Jr.

Veleair Smith, of West Virginia, thought this technique might be good for finding the depth of bedrock for geological purposes. Mr. Smith was specifically interested in whether Mr. Barnett's technique might have application to his investigations to find the depth of terminal moraine in the Grand River Valley of northeast Ohio. J. Osborn Fuller, also of Battelle and co-chairman with Dr. Van Pelt of the session, noted that a lot of people had tackled the problem in the Grand River Valley and the results of the studies varied. He said: "The reason for a study of the area is to develop the possibilities of building a canal from Lorain down through the Grand River Valley into the Ohio River near Youngstown. Youngstown is a big steel town and if iron ore and coal could be moved by water, freight cost would be reduced considerably. Mr. Smith was interested to know if these seismic investigations would tell anything about the character of the cap rock, for instance, whether it was pervious or impervious, but Barnett said that it would not." Mr. Fuller noted that the seismic method makes a very good reconnaissance tool to determine depth of bedrock for construction sites, but asserted drill holes would have to be used in the final analysis to check the indicated favorable areas.

Progress in trace element studies was discussed in a paper by Paul Kerr and D. L. Graf. These studies are being conducted to determine whether the presence and concentration of certain elements in the soil can be related to hidden ore bodies. Van Pelt sized up the situation in the following words:

"There are about four methods of geochemical prospecting, only two of which I consider as being really pregnant, the other two being like the woman who was only slightly pregnant. The pregnant ideas are trace elements in the soil, and trace elements in ground water. The slightly pregnant ideas are elements which stimulate or retard growth in plants, and plants which accumulate certain elements. Kerr was following up the trace elements in the soil idea by collecting samples in the well-defined mineral district of Santa Rita, New Mexico. The samples are collected from the soil and analyzed for the presence of various elements. If one or more elements seem to predominate and become greater in concentration at certain points when plotted on a map, they might indicate the presence of an ore deposit below the surface. Kerr's work is to set up a pattern by working in a known mineral area to determine what elements are good for tracer work. Lead was best, I think, silver being high up on the list. It is also important to discover that certain minerals are not related in any way to mineralization.

"Only a small group of men are doing any work on the subject. The U. S. Geological Survey is doing some. Work is being done on preferred elements for agricultural reasons, the results of which will be interesting to mining geologists. These studies are being conducted by spectrographic and wet analyses. Professor Kerr's and Graf's paper is one more building block in the picture which may ultimately lead to trace element investigations as a standard prospecting technique."

Mining Methods

Although there were several good papers on the Mining Methods two-session program, interest was fair to poor. Several authors were not present and, therefore, discussion of their papers was limited. The practice of wrapping pillars with cable to prevent sloughing at the St. Joseph Lead Co. mines in southeast Missouri was described in a paper by Wykoff. Although the technique is peculiar to this area it might have application in other large metal or nonmetallic mines using the room-and-pillar method. Another paper from St. Joe was written by E. A. James about development work with trackless equipment. It discussed the use of Joy loaders and shuttle cars but noted that drifts must be wider to permit their use.


Harry E. Nold

Louis Panek discussed a complicated subject in his paper on stresses about mine openings. Professor L. I. Cothern of Ohio State commented that the studies were based on the assumption of homogenous rock. However, he felt that such studies put mining on a scientific basis and more work of this nature was needed. Professor H. E. Nold, also of Ohio State, said that he would like to see studies made of the stresses about open-

ings created by various mining methods, and also the stresses created by various rates of extraction.

F. J. Haller and Joseph Bernhardt did a fine job in presenting their papers about ground support. The former described the use of steel for support at the Mather mine of the Cleveland-Cliff Iron Co., which they were finding cheaper than timber. Steel is being used to replace old timber sets on main haulageways. The steel is easy to handle, quickly erected, more durable, and takes up less space. Professor Nold said that it was necessary to use concrete footings when using steel in coal mines because of acid water. Timber columns to support steel caps were also used, he said. Mr. Bernhardt explained the technique of concreting slusher drifts and draw holes at Bethlehem Steel's Cornwall mine. All of the operators present were sympathetic to the difficulties caused by extremely heavy ground at this operaiton.

R. W. Jenkins traced the history of the development of drill jumbos and told of increased speed in drilling made possible by their use.

Minerals Beneficiation

Beneficiation Division sessions had plenty of what it takes to make a good meeting—good papers, well presented, and plenty of discussion. T. C. King described how he solved the problem of feeding a variable-moisture ore to the ball mills by using spiral classifiers. The two or three units in operation have shown good results although some water is used at the bins to insure uniform feed to the classifier.

The "Sage of Copperhill" made a progress report on his tricone mills. Smaller than normal balls and slower speeds are being used which result in a different grinding action in the mill. Mr. Myers has shown courage in incorporating many ideas gleaned from plant visits and AIME meeting discussions in his operation, and has predicted his results with remarkable accuracy. It will be a few years before the complete story is told, but Jack can be counted on to keep us posted.

John F. Myers

McQuiston did a fine thing in having a Belgian paper translated which dealt with the flotation of copper-zinc sulphide minerals. Tuwiner and Korman, in a paper on the flotation of chalcocite, opened up an old discussion, which Bob Ramsey and Herb Rose entered enthusiastically, on flotation as a power machine—it could be known as the "battle of the cubes." S. C. Sun presented two papers on his research work; one on the frothability of pine oils and the other on the behavior of mineral particles in electrostatic separation. All four papers in this group illustrated the need for the systematic study of fundamental problems.

Four papers were presented on operating control in unit processes. C. M. Marquardt has developed an electronic device for marking the belt where tramp iron is present. It came out that the idea is not new, Rose stating that he had used an electronic device to separate pyrrhotite. However, the idea of marking the belt is new as applied to mill work. A paper on statistical controls by Keyes and Dorenfeld came in for its share of discussion. Scott said that the authors did not get their point across, and there was some opinion that the work came out too early and should have been tied in with the experience of some mill operation. It was pointed out that statistical control had been particularly successful in the chemical industry, but mill operators have a different problem. The ore that comes from the mine varies from day to day and there are many variables on which to compile statistics, whereas in the chemical industry they are working with more or less constant analysis raw materials. However, records should be kept so that when the time comes there will be a basis for studying statistics of mill operation.

J. J. Bean discussed experience with density recording and control instruments for heavy-media separation, density control being particularly important in this process. It is common experience to have a lot of trouble with manometers in density controllers. When moisture condenses on top of the mercury, the system is thrown out of balance and must be reset. Bill Stephenson gave a paper on automatic control of sand pumps. He had a couple of teasers in it when he mentioned the different type drives, particularly magnetic. In describing experience with several installations, he showed how important the coupling is to smooth control of pumps.

Weston's talk on the Aerofall mill was a small sensation. The mill, it was reported, could take 18-in. feed and grind to finished size by virtue of a mechanical technique which might be termed "coupling action." The paper also started something which has been too long delayed, which is the use of different materials for grinding balls. Weston uses a small charge of tungsten carbide balls with a gravity of 14 in the Aerofall mill when certain materials are ground. The Aerofall mill is sensitive to moisture.

Considerable attention was attracted by Erck when he mentioned the large tonnages he was getting from a relatively small mill by using a low ball level and rushing the material right through the mill. The operation of the mill is controlled by watching the horsepower input per ton treated.

Industrial Minerals

The sparkling array of sixteen papers, plus a film, put on by the Industrial Minerals Division, deserved a crowded house, but the fair-sized group of constant attendants "ate up" the offerings and participated enthusiastically in the discussion.

The initial session was devoted to building materials and groundwater. John B. Patton of the Indiana Geological Survey presented an excellent perspective of the limestone industry of that state, attention having previously been directed to its building stone operations. He pointed out the distribution of the industry with reference to the limestone horizons and showed clearly the relations of the geological structures and glacial drift distribution, these two factors being complete determinants in the location of the industry. Richard Smith con-

Honorable Frank Lausche, Governor of Ohio: "Look toward Ohio when founding your industries because it has water, labor resources, transportation, and healthy environment."

gratulated Indiana on having sold the architects of the country on Indiana limestone. C. H. Bowen described (preliminary report) a deep test of the Maxville limestone in the Muskingum Valley. R. J. Anderson's paper on the raw material economics of the Ohio cement industry apparently is of a type of which more are needed, there having been no literature in this instance since the 80's. To get his material, the author visited all the cement operations in the state. Interest was expressed in his reference to air entrainment in cement. Only air-entrained cement is going now into Ohio highway construction. One operator told Mr. Anderson that all concrete soon will be air-entrained and the only question will be where the air is added. The manufacturers may not know why, but entrapment adds to the life of cement and the wearing qualities are good. It increases the cost per barrel very little.

An exploratory process, the results of which may serve as a pattern for isolating productive and nonproductive aquifers, one that might have much wider application to water reserves in limestone areas, was described by D. K. Hamilton reporting on occurrence of groundwater near Lexington, Kentucky. In discussion it was observed that in too many cases the stock farmer has gone on blindly drilling for water where he needs it instead of consulting his geological survey in advance. M. J. Morgan, of the Indiana Limestone Producers Association, showed with motion pictures how stone of unusual size is taken out of Indiana quarries. The beds are from 30 to 60 ft deep. Stripping varies with the terrain—practically none over 50 ft. Channeling by wire saw is being done now in some Indiana quarries.

There were four papers on mineral deposits. W. B. Mather presented a careful study of the various types of silica deposits in Arkansas, covering tripoli, novaculite, sandstone and quartzite, and sand and gravel. In a very good paper on Texas kaolin development, F. K. Pence pointed out a newly-discovered sandy kaolin deposit in which the kaolin properties are similar to those of Florida kaolin, but having some properties that would make it more useful. Apparently there are large reserves. A. B. Drescher described the raw materials used by the blast furnace of the Lone Star Steel Co., which consist of limestone and siderite deposits in Texas, high-volatile and low-volatile coal from nearby Oklahoma for making coke, and limestone and dolomite for flux from Texas and Oklahoma. Most of the manganese ore has come from a number of small mines in Zacatecos, Mexico. Other sources of manganese exist in Mexico, New Mexico, and the Batesville and Mena districts of Arkansas. According to Mr. Drescher, Lone Star Steel Co. has proved approximately 11,000,000 tons of limonite and 10,000,000 tons of siderite, with an additional 8,000,000 tons of limonite and 3,000,000 tons of siderite probable. These figures represent reserves only in the areas in which drilling or test-pitting has been done and the area represented is approximately 8% of the company's holdings.

Four papers had to do with preparation and new products. Richard K. Leininger dealt with the serious problem of getting pure limestone samples for spectrographic analysis, thus avoiding the contamination accompanying almost any means of getting samples. The Indiana Geological Survey is experimenting with methods of getting pure samples and is preparing to conduct the most extensive program of limestone analysis ever attempted. John D. Clarke discussed petalite—one of the oldest known lithium minerals, yet one of the least known and usually not identified because it looks so much like quartz—which is mainly found in South Africa. R. L. Stone presented the paper by G. A. Bole and K. B. Czarnecki dealing with techniques of bloating clays for use in lightweight aggregates.

Salt, without which man would perish, but, happily, of which there are tremendous reserves—trillions of tons—was the subject of four papers. John G. Broughton gave a very good description of New York State salt deposits. John A. Ames continued on down the map to Pennsylvania, Ohio, and West Virginia. Harry J. Hardenberg described the geology of the deposits in his state—there are two main salt horizons. Salt in industry and life was the topic assigned to W. G. Wilcox, who presented a scholarly history of the salt industry—man's need for salt, for animals, and in agricutlure. The physiological functions of many trace elements were studied and for no element studied were the functions the same as for salt. In fact, the study of salt from this point of view is just beginning.

At the Division luncheon on Wednesday, at the Neil House, there were short talks by AIME Secretary E. H. Robie, Division Chairman H. A. Meyerhoff, R. W. Smith, J. L. Gillson, and O. C. Ralston.

Coal

The Coal Division functioned well at Columbus with the largest group attendances, sometimes 150 or more, doing justice to the rich program. There were four technical sessions; one dealing with coal geology and synthetic fuels, the other three being respective symposia on (1) continuous mining, (2) roof bolting, and (3) air pollution. At the initial sessions, Norman K. Flint reported that the coal reserves of Perry County in southern Ohio are about one billion tons, which is only one half the reserves estimated for the county in 1912. Only seams of 14

in. and thicker were considered. This investigation is all part of a general plan to re-evaluate the coal reserves for the United States, in line with the thought of Crichton and others who are sure that our reserves will last only a few hundred years and not 4000 as estimated earlier by M. R. Campbell.

Reporting on an active program of coal geology in Illinois, Gilbert H. Cady emphasized the need for similar studies in other states. Coal operators are finding seams for future production by core drilling and other similar work, and the study of spores in known coal beds is of definite value in identifying the beds in neighboring regions which could not previously be correlated. There is a dearth of trained coal geologists, but three universities are now giving courses in that field—University of West Virginia, Colorado School of Mines, and the University of Pittsburgh.

D. Jones, Kentucky State Geologist, made an excellent discussion of Dr. Cady's paper. He emphasized the value of the current survey by the USGS on Kentucky coal reserves. To set up a state group for coal geology, Dr. Cady suggested a minimum of five or six men. Paul Price reported that his group has developed a machine for taking bed samples from floor to roof in each seam and in each county. R. H. Swallow stated that work is finally in progress to map the coal reserves of Indiana and to evaluate the minable areas.

According to William L. Crentz, J. D. Doherty, and E. E. Donath, low-ash coal is desired for hydrogenation and coal preparation must be directed to that end. For oil production by the Fischer-Tropsch process, the lowest possible sulphur is required in the prepared coal. W. H. Smith gave a short discussion of studies made in Ohio to produce oil from coal.

All the key developers of continuous mining machines in the country were present to discuss the problems involved and to illustrate with motion pictures the newest machines in operation. The discussion indicated that a continuous mining machine that combines all operations for liberating the coal from the seam and transferring to conveyances will be one of the salvations of the coal industry. Higher production per man day, elimination of the hazards of explosives, and better roof control have been demonstrated. Motion pictures of the Colmol and the Dosco continuous miners were shown.

According to J. R. Guard, the trend is definitely toward the use of a.c. instead of d.c. in the mines although the latter has advantages. The continuous mining machines, requiring up to 150 kw each, will require separate substations with a.c. supplied at high voltage to the substations, and possibly with high voltage supplied directly to the machines themselves. The three papers on roof bolting, by Edward Thomas, Lee Siniff, and John Raves, each showed great promise for increased safety and economies over the use of the conventional timbers and posts. For example, in the Elkhorn Seam of eastern Kentucky, Mr. Siniff supported the roof with bolts in a 40-ft wide room, which was previously unheard of in the Elkhorn Seam. The Bureau of Mines is pioneering the development with a small staff under the direction of Edward Thomas, and bolts 4 to 6 ft in length and approximately one inch in diameter are used. The bolts are threaded at one end and a slot is cut into the other. The slotted end together with a steel wedge is inserted into vertical drill holes through the roof strata. The bolts are driven in with force against the bottom of the hole to expand the upper end and thus secure anchorage. A plate at the lower end followed by a nut complete the assembly. The effectiveness is obtained by holding the laminations of the roof together in a single beam.

T. C. Wurts led off the symposium on air pollution with a discussion of some of the unknown air polluting solids of Allegheny County. L. C. McCabe outlined the attack on air pollution problems in Los Angeles County, where he was formerly in charge of reducing air pollution. Standards for the quantity of solids of discharge from metallurgical operations were formulated on the basis of careful measurements at numerous plants and H_2S from oil refineries in the county, which was formerly burned with the liberation of SO_2, is now being converted economically to elemental sulphur.

W. C. L. Hemeon, of the Industrial Hygiene Foundation, in discussion of the Wurts and McCabe papers pointed out that everyone wants to reduce air pollution and the apparent controversy or disagreement is on the best methods. Enlightened industry must gauge public sentiment and take proper steps in time to help solve the problem.

Henry F. Hebley emphasized with slides and data the atmospheric behavior which often holds in the ground layers of air the waste products that a turbulent atmosphere would disperse. The topography of Pittsburgh is especially conducive to fogs and smogs that are worst in the morning hours but are later dispelled through sun action by 11 a. m.

Carl E. Miller recommended a co-ordination of the research and development work on air pollution through the medium of the technical societies.

The Executive Committee met at luncheon on Tuesday, and the Division luncheon, E. R. Price, Chairman, presiding, was on Wednesday. Both affairs were well attended and between them practically every aspect of Institute and Division business was discussed.

Among notables at the speaker's table at the Mid-Year Banquet were: Clyde Williams, L. E. Young, Joseph W. Barker, and Hugo E. Johnson.

The Engineer's Bookshelf

Industrial Minerals and Rocks. Second edition, completely revised. The American Institute of Mining and Metallurgical Engineers, New York, 1949. Members, $4.50; nonmembers, $8.00; foreign nonmembers, $8.50.

When 27 technologists and scientists from industry, 9 professional consultants, 13 specialists from Federal and State bureaus, and 4 University professors can be brought together to give of their expert knowledge and precious time to produce an authoritative encyclopedia covering a field as broad as that of industrial minerals and rocks, it must be pronounced epochal. This is what was done in the production of the volume on Industrial Minerals and Rocks, second edition, completely revised. The volume has just been issued by the AIME with publication funds made possible by a grant from the Seeley W. Mudd Memorial Fund.

Compacted into this book of 1156 pages are 51 subjects, all calling for special treatment, scientifically, technologically, economically, and in some cases politically. Each subject is apportioned a chapter. Information is tersely presented on the physical and chemical nature of the material, its characteristics, distinctions, properties, varieties, origin and mode of occurrence, prospecting and evaluation, recovery, utility requisites in all their aspects, specifications, economic factors affecting their use and value, competing and supplementary substances, tests, producing sources, preparation for the market, size of the industry, variety of products and their uses, foreign brands where pertinent, statistics on production and price history, historical data, and information on political and commercial control and reserves. Indeed, the book is a survey of the whole field, thoroughly done. It shows the competent guiding hand of the Editorial Board of the Industrial Minerals Division of the Institute.

The book is richly documented with many valuable references on each subject and is well indexed. It is to be regretted that the space allotted to this review does not permit naming of the more than fifty authors to whom we are all indebted.

It was most appropriate that the Seeley M. Mudd Memorial Fund, established by one of the Institute's venerable members, Colonel Seeley W. Mudd, for the enduring benefit of young scientists and technologists in the mineral field, was employed in the publication of this volume—**Morris M. Leighton.** (For further information about this book, see p. 15—Ed.)

Mining Year Book, 1949. Compiled by Walter E. Skinner, 20 Copthall Avenue, London, E.C. 2, England. 536 p. $7, post-free abroad. The 1949 issue marks the sixty-third year of publication of Skinner's Year Book. It contains complete particulars on 874 companies operating throughout the world, and, in addition, the names of 966 mine engineers and managers. Also included are maps and plans of various properties, statistical tables on gold production, and a buyer's guide to manufacturers of mining equipment. This gold mine of facts and figures, now standard office equipment, is well worth seven dollars.

Conveyors and Related Equipment. By Wilbur G. Hudson. Second edition. John Wiley and Sons, Inc., 1949. 468 p. $7. This book is a detailed and comprehensive survey and analysis of the use and application of various methods of handling materials. Up-to-date information on pneumatic conveying, dust explosion hazards, the applications of motorized industrial trucks, and new developments in belt conveyor usage has been added to this second edition.

For Uranium Seekers. The Atomic Energy Commission and the USGS, prodded by thousands of queries, have jointly issued a handy booklet for uranium prospectors. It leads off with a description of the many types of uranium-bearing minerals, explains their occurrence in veins, sedimentary rocks, placer and pegmatite deposits, and gives directions for making electroscope, scintillation, photographic and bead tests for the fissionable material. A section describes the use of the Geiger counter. At the end of the 123-page publication are named the state and government laws pertaining to the staking of claims, government rights and powers, and licensing regulations pertaining to the production and sale of uranium ores. Send 30¢ to the Superintendent of Documents, U. S. Government Printing Office, in Washington, and the booklet is yours.

Engineering Economics and Practice, Including Solutions to Problems in Professional Engineer Examinations, New York State. By M. J. Steinberg and W. Glendinning. Apply W. Glendinning, 5123 Bell Boulevard, Bayside, N. Y., 1949. 101 p., diagrs., charts, tables. $3.—The basic principles of engineering economics and practice have been reduced to a formula basis with each of the terms clearly defined. Each chapter includes problems of a practical nature illustrating the principles involved. Questions and solutions to the problems in engineering economics and practice from the New York State Professional engineering examinations are an important supplement to the text material.

Conveyors and Related Equipment. By W. G. Hudson. 2 ed. John Wiley & Sons, New York; Chapman & Hall, Ltd., London, 1949. 468 p., illus., diagrs., charts, tables. $7.—This comprehensive treatment of the science of handling materials describes the application of a wide variety of equipment and analyzes the several kinds from the viewpoint of effectiveness. It provides a guide to the factors which must be considered when buying, equipping, operating and maintaining conveyors and related devices. The new edition contains an extended discussion of pneumatic conveying.

Constructive Uses of Atomic Energy. By S. K. Allison and others, edited by S. C. Rothmann. Harper & Brothers, New York. 1949. 258 p., illus., diagrs., charts, tables. $3.—This volume brings together fourteen articles by specialists describing the current uses of atomic energy in the fields of industrial power, chemistry, metallurgy, aviation, ceramics, soil-fertilizer research, biology and medicine, and pointing out the possibilities of future development. An appendix contains a glossary, a classified bibliography, and a chronological list of significant dates.

Mine Plant Design. By W. W. Staley. New second edition. McGraw Hill Book Co., 1949. 540 p. $7. An extensive revision of a well known text on mining. New chapters have been added on design principles, ore bins, skips and cages and safety catches. Information on underground diesel haulage and amplidyne control has been added, and the number of illustrations has been more than doubled.

aime NEWS

Mining Division Established at Sept. Board Meeting

Recognition of the Mining, Geology, and Geophysics Division of the AIME was accorded by the Board of Directors at their meeting on Sept. 27 at Columbus, Ohio. Some changes in the proposed bylaws of the new Division were believed desirable by the Board, and a committee consisting of Philip Kraft, chairman, with A. B. Kinzel and Donald H. McLaughlin, was appointed to work with the proposed executive committee of the new Division to draw up bylaws that would be acceptable to all the groups involved and to the Board. Temporarily, and pending acceptance of any revisions found necessary in the bylaws, Philip J. Shenon will act as Chairman of the new Division, and James K. Richardson, Secretary. They will also be Chairman and Secretary, respectively, of the Geology group in the new Division. Other members of the temporary Executive Committee of the Division are: J. Murray Riddell and O. A. Rockwell, Chairman and Secretary respectively of the mining group, and James B. Macelwane and Sherwin F. Kelly, Chairman and Secretary respectively of the geophysics group. Sub-committees will be appointed to permit the important work of the new Division to go forward until the time of the next Annual Meeting, or until a permanent organization is set up and approved by the Board. Among the important duties demanding immediate attention is the securing of papers for the Annual Meeting program and their review for acceptance for publication.

J. L. Gillson, chairman of the Special Committee on Democratization (E. A. Anderson and George B. Corless being the other members), made a report recommending formal organization of the "Council of Section Delegates" in line with the suggestions of the Johnson Committee, and offered provisional bylaws which would permit the Council to function at the forthcoming Annual Meeting. The Council would consist of a delegate from each Local Section, with traveling expenses paid to the Annual Meeting, each delegate normally serving for two years. For the first year, half of the Local Sections would elect a delegate for a one-year term, and half for two years; thereafter, half of the Sections would elect a delegate every year for a two-year term. This would assure that at least half of the delegates would have at least a year's experience. They would elect their own officers and prepare their own agenda, probably meeting at least a day before the Board meets so that any resolutions might be brought before the Board.

Announcement was made of the personnel of the Technical Publications Committees (which recommend acceptance or rejection of papers for publication) for the year beginning Oct. 15, 1949:

AIME: E. C. Meagher, chairman; Anthony Anable and Francis B. Foley, vice-chairmen; E. J. Kennedy, Jr., secretary; Robert H. Aborn, Vinton H. Clarke, Charles W. Eichrodt, Kenneth E. Hill, Paul F. Kerr, Charles H. Lambur, J. I. Laudermilk, W. H. Loerpabel, Earl W. Palmer, L. C. Raymond, J. E. Smart, Jr., Felix E. Wormser.

Auxiliary Publications Committees:

Coal Division: H. P. Greenwald, chairman; David H. Davis, Carroll F. Hardy, Raymond C. Johnson, H. J. Rose, G. A. Shoemaker, J. A. Younkins, Jr.

Extractive Metallurgy Division: Philip T. Stroup, chairman; Matthew A. Hunter, John D. Sullivan.

Industrial Minerals Division: H. D. Keiser, Chairman; Oliver Bowles, Oliver C. Ralston, Howard I. Smith, Richard W. Smith.

Institute of Metals Division: O. B. J. Fraser, chairman; W. C. Ellis, W. D. France, W. R. Hibbard, Jr., E. H. Hollingsworth, R. L. Rickett, R. P. Seelig, Ralph W. E. Leiter.

Iron and Steel Division: M. Tenenbaum, chairman; A. G. Forrest, B. R. Queneau, C. S. Smith, J. M. Stapleton, F. M. Washburn, Otto Zmeskal.

Minerals Beneficiation Division: M. D. Hassialis, chairman; S. R. B. Cooke, F. M. Lewis, S. D. Michaelson, H. Rush Spedden.

Mineral Economics Division: Charles H. Behre, Jr., chairman; Clayton G. Ball, Kenneth E. Hill, G. W. Josephson, Samuel G. Lasky.

Mineral Industry Education Division: Charles H. Behre, Jr., chairman; Thomas L. Joseph, William B. Plank, H. H. Power, A. W. Schlechten.

Petroleum Division: O. F. Thornton, chairman; J. M. Bugbee, vice-chairman; R. C. Craze, E. N. Dunlap, J. L. Hoyt, Jr., D. L. Marshall.

The secretary announced that no supplemental names had been received for nominations for Institute and Divisional officers for 1950 so that no letter ballot would be necessary.

A petition to organize a new Local Section of the Institute, composed of members working in the Florida phosphate industry, was approved by the Board. It will be known as the Florida Section, and would embrace the entire state, if this is agreeable to the petitioners.

Recommendations of appropriate committees for the award of Institute Medals at the forthcoming Annual Meeting were approved as follows:

Saunders Mining Medal to H. N. Eavenson.
Douglas Metallurgical Medal to Francis C. Frary.
Lucas Petroleum Medal to William E. Wrather.
Erskine Ramsay Coal Medal to Paul Weir.
Robert H. Richards Award to Arthur F. Taggart.
R. W. Hunt Award (silver medal) to J. S. Marsh.

J. R. Vilella has been selected as the Howe Memorial Lecturer for 1951.

THE DRIFT OF THINGS

... as followed by EDWARD H. ROBIE

Divisionalization Completed

Another of the major recommendations of the Johnson Committee, whose report was accepted by the AIME Board of Directors at the Annual Meeting last year, was finally brought to complete fruition at the September Board meeting. The Mining, Geology, and Geophysics Division was formally recognized, the last of the ten projected Divisions of the Institute. Practically every member should now find one Division to represent his technical interests, and many members whose interests are somewhat wider than usual will find it desirable to belong to more than one division. No fees for Divisional membership are assessed; membership merely puts one on the list to receive all announcements of Divisional meetings, permits one to vote for Divisional officers, and lists a member as available for Divisional committee work. A canvass is being made this fall to determine the Divisional affiliation of every Institute member, which will supersede all previous incomplete canvasses that have been made. This is not intended to change in any way the present selection of journals.

The Mining, Geology, and Geophysics Division, with the Minerals Beneficiation Division, the Coal Division, and the Industrial Minerals Division (Non-metallics) comprise the Mining Branch; the Extractive Metallurgy Division, the Institute of Metals Division, and the Iron and Steel Division comprise the Metals Branch; and the Petroleum Division is the only component of the Petroleum Branch, the Petroleum Branch and the Petroleum Division thus being synonymous. "Mining Engineering" contains all the papers published by the Mining Branch; the "Journal of Metals" all those of the Metals Branch; and the "Journal of Petroleum Technology" all those of the Petroleum Branch.

Two other Divisions complete the ten: the Mineral Economics Division and the Mineral Industry Education Division. The papers of these Divisions may appear in any one of the three journals, if of particular interest to the particular readership; or, if thought of interest to all members, may be included in the AIME News section.

Bylaws of the new Division were tentatively drawn up but several of the directors present at the September meeting believed they might be capable of improvement so their final acceptance was postponed, a committee being appointed to review them. However, a temporary executive committee representing metal mine operating men, mining geologists, and geophysicists, was appointed to act until all details have been worked out to the satisfaction of all concerned. This committee, of which Philip Shenon is chairman, with the aid of subcommittees, will solicit papers and prepare the program for the Division's sessions at the Annual Meeting in February, and will make recommendations to the Institute's Technical Publications Committee as to publication of papers in its field. Inasmuch as geophysics is not within the present interests of the Petroleum Branch, all geophysicists who are members of the Institute will presumably have their primary interest in this new Division.

The bylaws of the Institute provide that each of the three Branches have a governing council, which shall include one member from each of the Mineral Economics and the Mineral Industry Education Divisions, as well as at least one member from each of the constituent Divisions; further that council membership shall be equally divided between the constituent Divisions. No council has yet been set up for the Mining Branch, but it would have a minimum of six members, according to the bylaws, or it might have ten members, if each of its Divisions had two representatives instead of one. The Metals Branch Council must have a minimum of eight members, which it now has, consisting of A. A. Smith, Jr., chairman; Ernest Kirkendall, secretary; and D. S. Eppelsheimer, C. D. King, C. C. Long, F. N. Rhines, Gilbert Soler, and J. D. Sullivan. The Petroleum Branch council is required to have a minimum of six members, but currently has ten, or eleven if the Treasurer be included. This council is synonymous with the officers of the Petroleum Division.

National and Divisional Meetings

When the Institute had all of its Annual Meetings in New York, and few Divisional meetings, it was customary to have at least one Institute meeting each year in another part of the country, usually in the fall, which became known as a Regional Meeting, or, more recently, the Mid-Year Meeting.

Some, at least, of the reasons for these mid-year meetings have now ceased to exist. The experiment of having occasional Annual Meetings outside of New York has proved successful, with the 1946 meeting in Chicago and the 1949 meeting in San Francisco; the 1951 Annual Meeting is scheduled for St. Louis, and the 1953 meeting may be held in Los Angeles. Thus members in North America, no matter where they live are not too far away from at least an occasional Annual Meeting. Another reason why all-Institute mid-year meetings are no longer so necessary is the desire of the various Divisions of the Institute to have their own meetings. The Petroleum Branch thus has the established practice of having one meeting in the fall of each year in the Mid-Continent or Gulf Coast areas and

one in southern California. The Institute of Metals Division customarily meets at the same time and place as the American Society for Metals, during the National Metal Congress, and also in the spring at an Eastern city. The Iron and Steel Division, through its Blast Furnace and Raw Materials, Open Hearth, and Electric Furnace Committees, has several national and regional meetings in the course of a year. The Coal Division for years has united with the Fuels Division of the American Society of Mechanical Engineers in a Fuels Conference in the fall. The Industrial Minerals Division has customarily held an Eastern and Western meeting of its own each year, this year three such meetings being scheduled—at Tampa, Golden, and Los Angeles.

No fall meeting being scheduled for 1950, two other Divisions are contemplating meetings a year hence: The Minerals Beneficiation Division at Duluth, and the Mineral Economics Division at Washington. Conceivably the new Mining, Geology, and Geophysics Division or the Iron and Steel Division might wish to participate at Duluth.

Whether or not the usual fall meeting of the Institute should now be discontinued is therefore something to consider, and the opinions of members will be welcomed. Even should they be discontinued as annual fixtures, an occasional special meeting of the Institute might be held in the summer or fall.

The Secretary Goes Afield

Progress in reorganization having reached a point where continuous duty in New York did not seem quite so necessary, and where some first-hand reactions of the membership to what has been done seemed desirable, we set out in the family Ford on Sept. 22 to take the issues to the voters.

Our first business stop was Columbus, Ohio, for the Mid-year meeting. From the standpoint of the variety and number of technical papers presented this was perhaps the most successful fall meeting the Institute has ever staged. The local committee worked hard and successfully to assure a smooth-running meeting in every respect.

After leaving Columbus we enjoyed a luncheon meeting with Art Focke and a group of AIME members in Indianapolis; an early meeting there is planned. Art is a loyal Institute member as well as the president elect of the ASM. Next day we had a luncheon meeting with the officers of the St. Louis Section, and talked over plans for the Annual Meeting in that city in 1951.

That same night we arrived at Rolla, Mo., where we had a dinner meeting with some of the faculty and students and their wives, followed by a meeting of the Student Chapter. The mining school at Rolla now boasts of more than 500 students, has many distinguished graduates, and promises to extend the relative number of its graduates in the world's mining camps. The next day was Sunday, but that did not prevent the officers of the Tri-State Section from gathering with us at the home of its Secretary, J. C. Stipe, in Baxter Springs, and listening to the World's Series game. We managed to work in mention of AIME affairs during the commercials.

Then on to Muskogee for the night and more than 400 miles through rain the next day to Austin, where we arrived just in time to give a talk before the petroleum engineering students. On the way we had lunch with the Petroleum Branch staff at Dallas, with the exception of Bill Strang, who had gone on to San Antonio to prepare for the fall meeting of the Branch. Even with Bill absent, we can assure all AIME members visiting in Dallas, whether petroleum men or not, that they will enjoy meeting Joe Alford, editor of JPT, and his capable assistant, Mrs. Haywood; and should not miss the smiles and eye twinkles of Peggy Hardy.

In past years we have heard of the great success of the fall petroleum meetings but we have never had the privilege of attending one since we took our first airplane ride in a Ford tri-motor plane to the Ponca City meeting some fifteen years ago. At least 1200 people attended the San Antonio meeting; almost exactly 900 men were registered, and at least 300 ladies were present. We were enormously impressed with the technical program, which was mostly over our head, but which quite evidently had many important papers on concurrent sessions for three days; with the type and number of the people present; with San Antonio as a locale for the meeting; and with the social features. One cannot but notice that Petroleum Branch members are relatively young men—few gray hairs and bald heads were evident—and that they bring to the meetings and to the Institute all the enthusiasm of virile youth. The Branch has been particularly sucessful since the Dallas office was established, and a similar field office for the Mining Branch in Utah or Colorado seems indicated. At the dinner dance at the Seven Oaks Club, a most attractive spot a few miles north of the city, 860 persons were served under ideal conditions. As a special feature the Texas boys staged a full eclipse of the moon, which took place entirely within the time the group was partaking of the al fresco dinner. It must be admitted, however, that the Mexican singers and dancers attracted greater interest.

Following San Antonio, our next stop was Carlsbad, where we had a luncheon meeting with the officers of the Carlsbad Potash Section. This local group, representing but one industry in a closely limited area, has had most successful monthly meetings, and has done much in increasing co-operation among the three companies that are operating in the area. From there we dropped down to El Paso in the afternoon and next morning went up on the hill to talk to the students at Texas Western College. Gene Thomas, John Graham, and Guy Ingersoll seem to be doing a fine job here in turning out mining engineers. A luncheon meeting with the officers of the El Paso Metals Section at the del Norte followed, with Ed. Tittman presiding. No doubt we should admit that we did get in a bit of recreation at Juarez the night before. We can recommend the Charmant as a place to dine, and if one does not have the opportunity to visit the Carlsbad cavern, the Cave of Music is a reasonable artificial facsimile of a small part thereof. The only disappointing feature of our trip to Juarez was our neglect of the opportunity to buy the allowed gallon of liquor, which can be obtained for about one-third of the U. S. price, or about $1 for Bacardi rum.

Personals

Richard C. Anderson completed his course in mining engineering at the New Mexico School of Mines last July and is employed by the Allis-Chalmers Mfg. Co. His new address is 1021 N. 39th St., Milwaukee 8, Wis.

T. J. Ballard has resigned from the Bureau of Mines to take the post of general manager of the Dunbar Corp., Dunbar, Pa. This Corporation has extensive coal and silica sand deposits, owns the New Haven and Dunbar Railroad and produces a high quality glass sand for various glass plants of the region.

A. T. Barr has been promoted from mine superintendent to general superintendent of the New Cornelia copper mining branch of the Phelps Dodge Corp. at Ajo, Ariz.

James A. Barr, Sr., retired as chief engineer of the International Minerals and Chemical Corp., Chicago, after 38 years of service, and then was appointed consulting engineer for the concern. He has opened an office as a consulting engineer specializing in nonmetallics and can be reached at his home at 505 Haylong Ave., Mt. Pleasant, Tenn.

A. H. Barrios, recent Mackay School of Mines graduate, is employed by the Anaconda Copper Mining Co. and is taking their special training course for junior engineers. His address in Butte is 733 W. Park St.

Robert R. Bergis resigned as salesman for the Atlas Powder Co. in August and is now associated with the Industrial Supply Co. in Roseburg, Oreg.

M. John Bernstein has returned to the Colorado School of Mines to study for his master's degree in mining.

C. A. Botsford left New York on Sept. 28 for Siam and Burma as a consultant for New York industrialists interested in tin, tungsten, and lead mining. He returned to the States last May after 27 months as chief of the minerals branch, mining and geology division, Natural Resources Section of General MacArthur's headquarters in Tokyo.

Alan T. Broderick has gone to Kellogg, Idaho, as a geologist with the Bunker Hill & Sullivan Mining and Concentrating Co.

John G. Broughton has been made New York State geologist. He had been assistant state geologist.

Brinton C. Brown is a mining engineer with the Bureau of Mines at the experimental oil shale mine, Rifle, Colo.

Leroy T. Brown has been working for the W. H. Loomis Talc Corp. since last spring. His address is P. O. Box 267, Gouverneur, N. Y.

H. M. Corley

H. M. Corley has been appointed manager of the chemical division of Armour & Co. He joined the Company in 1927 with most of his work devoted to the development of new chemicals, commercial processes for manufacturing them, and new products in which these new chemicals could be used. He is responsible for chemical plant management and operation, chemical sales, market development and market research on new items.

Arno C. Fieldner

Arno C. Fieldner, chief of the fuels and explosives division of the Bureau of Mines, was honored with the distinguished service award and gold medal by the Department of the Interior in recognition of his notable contributions to fuel technology during forty years of service.

Donald F. Campbell has changed his address from Rio de Janeiro, Brazil, to care of Geophoto Services, 305 Ernest & Cranmer Bldg., Denver 2, Colo.

James B. Chaney is with the Baroid Sales Division, National Lead Co., Box 218, Potosi, Mo.

Denton W. Carlson has had a memorable year; he got his B.S. in mining engineering from Stanford, was married on June 20, honeymooned through several Western States, and was employed by the Anaconda Copper Mining Co. on a two year training program.

Glenville A. Collins returned to his offices in Santa Barbara, Calif., after a busy summer examining uranium properties in Canada.

H. R. Cooke, Jr., formerly with the Chile Exploration Co. in Chuquicamata, has gone to Llallagua, Bolivia, to work for Patino Mines & Enterprises Consolidated.

Francis X. Corbett is in Georgetown, Colo., working for Gold Mines Consolidated, Inc., in the capacity of operating engineer.

William J. Coulter has been made a vice-president in charge of mining operations for the Climax Molybdenum Co. With the Company since 1927, he has been manager of mining operations since 1934.

K. N. Das has been touring the States studying field problems in mining and engineering geology, ground water and soil conservation methods as part of a MIT practical program. He has gone to England and Europe now for observational studies on reclamation problems.

David B. Dill, Jr., is in Monterrey, Mexico, with Cia. Minera de Penoles.

James S. Dodge, Jr., employed by the Natural Resources Section, GHQ, SCAP, Tokyo, Japan, since September, 1946, has resigned as deputy chief, mining and geology division, following completion of a draft for the report "Manganese Resources of Japan" to take graduate studies in economic geology at Stanford University beginning the fall quarter.

C. P. Donohoe has gone to Cananea, Mexico, as general superintendent of the Cananea Consolidated Copper Co.

A. Emond is in San Felix, Edo. Bolivar, Venezuela, on a two year contract with the Iron Mines Co. of Venezuela, a subsidiary of the Bethlehem Steel Corp.

Frank M. Estes has returned to the States from Colombia where he spent

the last seventeen years. His present address is 208 E. Cherry Circle, Memphis, Tenn.

Louis W. Ferguson is temporarily attached to the Economic Co-operation Administration and can be reached at the Strategic Materials Division, 800 Connecticut Ave., Washington 25, D. C.

P. V. G. Ford has been appointed assistant general manager of the Sinai Mining Co., Abu Zenima, care Port Said and Suez Coal Co., Port Twefik, Egypt.

R. E. Froiseth, after spending 2½ years as project manager for Drake-Puget Sound Contractors on Naval construction in the Aleutian Islands, has decided to take a long rest and absorb some California sunshine. His address is in care of N. W. Howard, 521 Toro Canyon, Santa Barbara, Calif.

Daniel Geary has enrolled at the Montana School of Mines to complete work for a degree. His address is 1421 W. Porphyry, 413 Mines Vets Homes, Butte.

Latham B. Gray, Jr., has finished his studies at the Michigan College of Mining and Technology, receiving a B.S. degree in mining engineering. He is employed by the Bethlehem Collieries Corp., subsidiary of Bethlehem Steel, at Idamay, W. Va.

K. B. Gross, formerly with the New Guinea Goldfields, Ltd., has accepted an appointment as assistant general manager of Mount Isa Mines, Ltd., Mount Isa, Queensland, Australia.

W. J. Guay has changed his address from the Howe Sound Mining Co., Holden, Wash., to Apt. 4, 826 E. Center St., Pocatello, Idaho. He is now employed by the Westvaco chemical division of the Food Machinery and Chemical Corp.

Graham Hall, who is assistant superintendent and chief geologist of Electrolytic Zinc Co. of Australasia, Ltd., west coast department, at Rosebery, Tasmania, visited various mining centers in the United States and Canada during July, August and September.

John R. Hallock, a Colorado School of Mines man, is working for the Idarado Mining Co. at Ouray, Colo.

J. L. Hamilton has severed relations with the Republic Steel Corp. and is now employed by the Island Creek Coal Co., Pond Creek Pocahontas Co., and Marianna Smokeless Coal Co. as vice-president in charge of operations.

Robert L. Hamilton has the job of hydraulic engineer with the International Boundary and Water Commission, Alpine, Texas, working on field measurement of water flow.

R. S. Handy, formerly mill superintendent for the Bunker Hill & Sullivan Mining & Concentrating Co., Kellogg, Idaho, has retired as consulting metallurgical engineer for the company and he and Mrs. Handy have moved to 2329 Humboldt St., Santa Rosa, Calif., where he intends to try his hand at flower gardening.

James Gibson

James Gibson, who has been employed for the past five years in placer examinations for the American Smelting and Refining Co., has left AS&R to engage in placer mining in Peru. His present address is Quincemil, via Cuzco, Peru.

Tommy Martin

Tommy Martin, head of the French Advisory Mission at Camp Sherman, Chillicothe, Ohio, in 1917 and 1918, now a consulting engineer, can be reached in Megrine, Tunisia.

J. D. Harlan, since resigning as a vice-president of U. S. Smelting Refining and Mining Co., although not out after professional work, has undertaken some special tasks, including two trips to France and Maroc, and one to Berlin and the Ruhr industrial district. In June he completed a mining engineering assignment at the Hazleton shaft of the Lehigh Valley Coal Co. and in September was at Wilkes-Barre, Pa., on similar work. His permanent home address is still 2017 5th Ave. N., Seattle 9.

Donald F. Haskell can be reached at the Benguet Consolidated Mining Co., Baguio, Philippine Islands.

Earl F. Hastings has been appointed director of the securities and investments division of the Arizona Corporation Commission. In accepting this appointment he resigned as secretary-treasurer of the Western Perlite Corp. and dropped his mining and metallurgical consulting practice.

Arthur W. Heuck can be reached now in care of Cyprus Mines Corp., Skouriotissa, Nicosia, Cyprus.

Warren H. Hinks, Jr., since his graduation in June from Penn State, has been employed as a mucker by the U. S. Smelting Refining and Mining Co. at their Lark mine.

Francis G. Hoffman is working for the Homestake Mining Co., Lead, S. Dak., as a mine surveyor. His home address in Lead is 214½ Arlington St.

Edward Holloway, surviving partner of Douglas, Armitage & Holloway, has formed a partnership for the general practice of law with members of the firm of Bannister, Stitt & Krause, under the firm name of Bannister, Stitt, Holloway & Krause with offices at 40 W. 40th St., New York 18.

R. C. Howard-Goldsmith is now employed as a mine foreman by the Cerro de Pasco Copper Corp., Cerro de Pasco, Peru.

Charles D. Hoyt, having received one of the Fulbright Scholarships that are offered by our Government to graduate students in foreign countries, has gone to the Institute of Technology at Trondheim. He plans to spend the year observing the various phases of Norway's mining industry.

Hsi Keng Hu is employed as assistant mill superintendent by Cia. American Smelting Boliviana, a subsidiary of American Smelting and Refining, and is addressed in care of the Company, Casilla 901, La Paz, Bolivia.

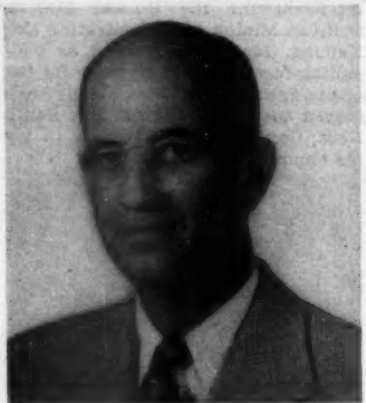
Paul W. Hughes has changed his address from the Dept. of Geology, University of Arizona, Tucson, to the Museum of Northern Arizona, Flagstaff.

Gordon E. Irving is ore testing engineer for the Allis-Chalmers Mfg. Co., West Allis, Wis.

Lytton Francis Ivanhoe, Jr., who received his B.S. degree in mining in

1942 from the South Dakota School of Mines, and who has been attending Stanford University, has recently been employed as mining engineer by the Standard Oil Co. of California in the exploration department, 11-C Camp, Taft, Calif.

Gunnar S. Johnson, general manager of the East Chicago, Ind., plant of the Eagle-Picher Co., retired from active duty on Aug. 1 When Eagle-Picher purchased this plant in 1946, he was granted a leave of absence from Anaconda to assist in the initial operations. Mr. Johnson leaves the East Chicago plant after 31 years of active duties in capacities from research chemist to general manager. He plans to retire to his farm in the Catskills and to spend part of the time with his family in Florida.



J. D. McClintock

J. D. McClintock recently returned to the States from an assignment with the United States Philippine War Damage Commission. He was in charge of appraisal and allocation of payments to mining operations in the Islands.

Roy Johnson on July 1 was appointed manager of the central industrial division of The Dorr Co., with headquarters in Chicago. **H. W. Hitzrot,** of New York, previously handled this territory of the industrial division in addition to his regular duties as manager of the eastern industrial division.

Robert W. Johnson, formerly of Lead, S. Dak., can be reached in care of the Braden Copper Co., Rancagua, Chile.

Vard H. Johnson, of the U. S. Geological Survey, has started an investigation of the coking coal and geological

Coming Meetings

NOVEMBER

1 Society for Applied Spectroscopy, New York City.
1-5 Pacific Chemical Exposition, California Section, American Chemical Society, San Francisco Civic Auditorium.
2 Chicago Section, AIME. Ladies Night. J. P. Skinner on "Synthetic Sapphire."
2-4 American Society of Civil Engineers, fall meeting, Washington.
4 Columbia Section, AIME.
7 Boston Section, AIME.
7-10 AIChE, annual meeting, Pittsburgh, Pa.
7-12 International congress on tunnel driving in rock formation, organized by the Societe de l'Industrie Minerale. Information on meeting available from French Mining Mission, 1322 18th St., N. W., Washington, D. C.
8 Delta Section, AIME. Problems of offshore drilling.
8 East Texas Section, AIME.
8-11 Industrial Minerals Division, AIME, Tampa, Fla.
9 El Paso Metals Section, AIME.
9 San Francisco Section, AIME.
9 New York Section, AIME. Ladies Night. C. Goodman on "Atomic Energy."
10-11 National Air Pollution Symposium, Huntington Hotel, Pasadena, Calif.
10-14 ASTM, first Pacific area national meeting, San Francisco, Calif.
11-12 Central Appalachian Section, AIME., and W. Va. Coal Mining Inst., Summit Hotel, Uniontown, Pa.
11 Rio de Janeiro Section, AIME.
12-14 Geological Society of America, annual meeting, Hotel Cortez, El Paso.
14 Arizona Section, AIME, annual meeting, Pioneer Hotel, Tucson.
15 Gulf Coast Section, AIME.
15 Washington, D. C., Section, AIME.
16 Southwest Texas Section, AIME.
16-18 Industrial Hygiene Foundation, 14th annual meeting, Mellon Institute, Pittsburgh.
16-18 Geological Society of America, annual meeting, Hotel Statler, Washington, D. C.
17 Carlsbad Potash Section, AIME.
17 Utah Section, AIME.
18 Oregon Section, AIME.
18 St. Louis Section, AIME, joint meeting with Woman's Auxiliary.
21 Detroit Section AIME.
22 Montana Section, AIME.
26 Wyoming Section, AIME, fall meeting, Townsend Hotel, Casper.
27-Dec. 2 ASME annual meeting, Statler Hotel, N. Y. C.
28 Alaska Section, AIME.
28-Dec. 3 22nd Exposition of Chemical Industries, New York City.

DECEMBER

2 Columbia Section, AIME.
4-7 AIChE, national meeting, Pittsburgh, Pa.
5 Boston Section, AIME.
6 Society for Applied Spectroscopy, New York City.
7 American Mining Congress, Annual Business Meeting, New York City.
7-9 Eighth Annual Conference, Electric Furnace Steel Committee, Iron and Steel Division, AIME, Hotel William Penn, Pittsburgh.
7 Chicago Section, AIME. W. C. Schroeder on synthetic liquid fuels.
7 New York Section, AIME. L. E. Young on research in coal mining.
8-10 Seventh Annual Conference, Electric Furnace Steel Committee, Iron and Steel Division, AIME, Hotel William Penn, Pittsburgh.
9 Rio de Janeiro Section, AIME.
9 St. Louis Section, AIME, York Hotel.
13 Delta Section, AIME. W. H. Skinner on gas condensate well corrosion problems.
13 East Texas Section, AIME.
14 Connecticut Section, AIME. F. H. Wilson on intergranular parting of 70:30 brass.
14 El Paso Metals Section, AIME.
14 San Francisco Section, AIME.
15 Carlsbad Potash Section, AIME.
15 Utah Section, AIME.
16 Oregon Section, AIME.
26-31 AAAS, Penn zone hotels and Columbia Univ., New York City.

JANUARY 1950

18-20 American Society of Civil Engineers, annual meeting, New York.
30-Feb. 3 AIEE, winter meeting, Hotel Statler, New York.

FEBRUARY 1950

10 Southwestern Section, Open Hearth Steel Committee, Iron and Steel Division, St. Louis, Mo.
12-16 Annual Meeting, AIME, Statler Hotel, New York City.

APRIL 1950

4-7 Nat'l Assn. of Corrosion Engineers, St. Louis.
10-12 Open Hearth Conference, and Blast Furnace, Coke Oven and Raw Materials Conference, Netherlands Plaza Hotel, Cincinnati.
19-21 American Society of Civil Engineers, spring meeting, Los Angeles.
23-26 American Ceramic Society, annual meeting, New York City.
24-26 AMC Coal Convention, Netherlands Plaza Hotel, Cincinnati, Ohio.

DECEMBER 1950

7-9 Electric Furnace Steel Conference, Iron and Steel Div., Hotel William Penn, Pittsburgh.

APRIL 1951

2-4 Open Hearth and Blast Furnace, Coke Oven and Raw Materials, Conference, Iron and Steel Division, Statler Hotel, Cleveland.

mapping of the Grassy quadrangle south of Sunnyside, Utah. Headquarters are in the Federal Bldg., Salt Lake City. The report of the Mount Gunnison quadrangle, in Colorado, is being processed for publication.

Robert B. Johnston, formerly a student at the Otago School of Mines, is a mining engineer for the General Mining and Agency Co. in Kuala Lumpur, Malaya.

Jesse C. Johnson has been appointed to the newly established post of deputy manager, AEC Raw Materials Operations Office, Washington. He had been assistant manager in charge of domestic production. He will assist Manager **John K. Gustafson** in administering the entire AEC program for the acquisition and production of all raw materials including uranium, used in the national atomic energy program. **F. H. MacPherson,** former manager of the Polaris-Taku Mining Co. in Vancouver, B. C., has been appointed manager of the AEC Raw Materials Office in Grand Junction, Colo.

Helene Klein, formerly on the staff of ME, is now in Paris. When last heard from, she was vacationing in Italy, but intended to return to Paris in the fall to find a job.

Keith Kunze has taken the job of mill superintendent of the Central Eureka Foundry Co., Sutter Creek, Calif. He had been mill foreman for the Resurrection Mining Co.

Eric J. Langevad has resigned as exploration engineer for the Electrolytic Zinc Co. of Australasia to accept the post of section manager for Kenya Consolidated Goldfields, Kitere, Kenya Colony, British East Africa.

Herbert H. Lauer, plant manager of the Glens Falls Portland Cement Co. for the past 6½ years, resigned that post on Sept. 30 to go into consulting engineering with headquarters in the Land Title Bldg., Philadelphia. Mr. Lauer has had over thirty years of cement and industrial plant design, construction, operation, and management experience both at home and abroad.

S. H. Lorain, who has been chief of the Albany division mining branch of the Bureau of Mines, has transferred to the Alaska station of the Bureau at Juneau.

Frank E. Love, who has been in Alaska for the U. S. Smelting Refining and Mining Co., has returned to the States and is living in Boulder City, Nev.

R. J. Mechin, manager of the Edwards Division at Balamt, N. Y., of the St. Joseph Lead Co., has moved to the Company's New York office.

T. H. McClelland returned to Colombia on Oct. 14 after a five month vacation in the States. He resumes his post of field manager for Asnazu Gold Dredging Ltd., at Asnazu.

J. B. McKay

J. B. McKay can be reached in care of Campbell Red Lake Mines, Balmertown, Ont. He arrived there last March, getting in on the start-up of a 65-ton fluid-type roaster. Since the fluid-type roasters are not far beyond the development stage, he finds it most fascinating and when all the roasting plant problems are ironed out, there will still be plenty of work left on the metallurgy, since this may well be the most complex flow sheet of any gold mill anywhere.

Ken Merklin has been transferred to Hibbing, Minn., as Mesabi range sales representative for the Western Machinery Co. **Galen de Longchamps** recently resigned as manager of the Hibbing office to move to California.

George F. Meyer, Jr., is with the engineering division of the Empire Zinc Co., Hanover, N. Mex.

Robert A. Mitchell, with the RFC, has been transferred from Washington, D. C., to Los Angeles. His address there is 949 Mullen Ave.

Have You Done It?

Have you remembered last month's request for up-to-date information for the 1950 Directory? Have you done anything about it?

If you have a new address, a new company affiliation, a new job, please advise us. Your Directory listing will be the same as it was in the 1948 edition if you haven't brought headquarters up to date. And if and when you change that address, please include your previous address and Branch—Metals, Mining, or Petroleum—affiliation.

Crispin Oglebay has resigned as president of Oglebay, Norton and Co. He is chairman of the board.

Khem W. Palmer, Jr., is working for the Bethlehem Collieries Corp. of Johnstown, Pa.

William C. Peters, formerly a geologist with the Empire Zinc Division of the New Jersey Zinc Co., is now on the faculty of Idaho State College as an instructor in geology. His home address is 201 Campus Drive, Pocatello.

Bruce R. Pickering is an underground mine worker for Blackwater Mines Ltd., Waiuta, New Zealand.

Victor J. Pittson, formerly on the engineering staff of the Howe Sound Exploration Co., Snow Lake division, is now with Madsen Red Lake Gold Mines Ltd., Madsen, Ont.

Morton E. Pratt, Jr., became metallurgist at the Round Mountain Gold Dredging Corp., Round Mountain, Nev., on Oct. 1. He had been research engineer for Yuba Consolidated Gold Fields.

David C. Minton, Jr.

David C. Minton, Jr., assistant to the director of Battelle Memorial Institute, has been made executive in charge of sponsor relations and projects development, acting as liaison between Battelle and industrial and governmental sponsors conducting research at the Institute. He has been with Battelle since 1941, except for a period during the war when he was in Washington with the war metallurgy committee of the National Academy of Science and National Research Council and the National Defense Research Committee of the Office of Scientific Research and Development.

Walter R. Ziebell is an instructor at the University of Miami in the department of geology, teaching mineralogy, economic geology, historical and physical geology.

—In the Metals Branch—

Charles R. Cook, Jr., is working as research metallurgist for the Titanium Division of the National Lead Co. at South Amboy, N. J. His mail goes to Box 284A, RFD 1, Metuchen, N. J.

Gerrit De Vries recently moved to California where he is employed as a metallurgist with the Naval Ordnance Test Station in Pasadena. His home address is 1618 Brycedale Ave., Duarte, Calif.

R. S. French and **W. T. Toussaint,** both with the Bridgeport Brass Co., received Master of Engineering degrees from Yale last June.

John E. Fries, Jr., is with the national bearing division of the American Brake Shoe Co., Meadville, Pa.

A. F. Gallistel, Jr., has left the Minneapolis Honeywell Co., where he was a design engineer, to become chief engineer for the Perfection Mfg. Co., Minneapolis, Minn.

Paul Gordon is assistant professor of physical metallurgy in the department of metallurgical engineering at the Illinois Institute of Technology, Chicago.

James C. Hartley

James C. Hartley has been appointed a staff executive of Winchester Repeating Arms Co., a division of Olin Industries, Inc., of New Haven, Conn. He will handle special assignments for the regional manager. Mr. Hartley was vice-president and general manager of Barium Steel and Forge, Inc., and had his own metallurgical consulting office in New York City.

Earl A. Hasemeyer is employed as a metallurgical engineer by the Western Cartridge Co., East Alton, Ill.

L. E. Householder transferred from the McCook plant as chief plant metallurgist to the main office of the Reynolds Metals Co., Richmond, Va., as assistant chief metallurgist.

Robert R. Kupfer has finished work for his B.S. degree in metallurgy at Montana School of Mines and is studying for his master's degree in mineral dressing. His address is 1221 W. Porphyry St., Apt. 609, Butte.

Paul D. Merica

Paul D. Merica, executive vice-president of the International Nickel Co. of Canada, was elected a director of the Babcock & Wilcox Co. on Sept. 22.

Gilbert M. Leigh became research engineer for the Colgate-Palmolive-Peat Co., Jersey City, N. J., on Sept. 1.

C. R. Lillie, having recently completed three years of graduate work at Carnegie Tech, has taken the post of technical aide to the committee on ship steel of the National Research Council, Washington.

W. M. Mahan returned to his former headquarters at the Bureau of Mines sponge iron plant, Laramie, Wyo., after a six month transfer to the Bureau's Salt Lake City Station. The Laramie plant is in standby condition with plans for the future indefinite.

W. E. Mahin, recently appointed director of research at the Armour Research Foundation, has been made a member of the National Research Council for a three-year period. He will represent the ASM.

John D. Mitilineos graduated from the Colorado School of Mines last June and since then has been a metallurgical engineer with the American Platinum Works, Newark, N. J.

Frank C. Moran became superintendent of smelting for Mount Isa Mines Ltd., Mount Isa, Queensland, Australia, on June 1.

F. D. L. Noakes recently gave up his post as lecturer in metallurgy at the Royal School of Mines, London, to take up a new job as refinery metallurgist with the Rhodesia Copper Refineries Ltd., N'kana, Northern Rhodesia.

Edward P. Quick has been employed as a practice engineer in the blast furnace department of the Wheeling Steel Corp., Steubenville, Ohio, since graduating from Penn State last June.

W. Spencer Reid is manager of the Utah Department of the American Smelting and Refining Co., Selby, Calif., succeeding **R. D. Bradford,** who is now general manager.

Gene D. Selmanoff received his M.S. degree in metallurgy at the University of Minnesota last July. Since then he has been working for the Institute for the Study of Metals at the University of Chicago.

DuRay Smith resigned from the Union Spring and Mfg. Co., New Kensington, Pa., on June 1, to live in Phoenix, Ariz., near his small citrus grove. His search for "that place in the sun" has taken him to 3030 N. 7th St., Phoenix.

Morty Schussler

Morty Schussler is working at the gaseous diffusion plant of the Carbide and Carbon Chemical Corp., Oak Ridge, Tenn., as a metallurgist in the metallurgy division. He was with the Caterpillar Tractor Co.

Hubert C. Smith, chief metallurgist of the Great Lakes Steel Corp., has been made assistant vice-president in charge of metallurgical control. This new post was created in recognition of the increased responsibilities for production quality accompanying the plant's expansion program.

Harry H. Stout, Jr., has been made assistant director for contract administration for the Franklin Institute, Philadelphia. After service in the Army, which he left with the rank of Lieutenant Colonel in the Ordnance Department, in 1946 he became director of the new projects division of the Franklin Institute Laboratories for Research and Development.

William R. Toeplitz, who is vice-president in charge of engineering research for the Bound Brook Oil-Less

Bearing Co., has been elected to the Company's board of directors.

Alexander R. Troiano, formerly on the staff at Notre Dame, is professor of physical metallurgy at Case Institute of Technology, Cleveland, Ohio.

Roy Erwin Swift

Roy Erwin Swift, formerly of the faculty of the school of chemical and metallurgical engineering of Purdue, was awarded the degree of doctor of engineering by Yale in June. He has joined the faculty of the Mackay School of Mines at Reno to teach mining and metallurgy.

R. J. Turney can be reached at Mount Isa Mines, Ltd., Mount Isa, Queensland, Australia.

Ferdinand L. Vogel, Jr., is working for the American Smelting and Refining Co., Barber, N. J., as a research metallurgist. His permanent address is 59 Freneau Ave., Matawan, N. J.

R. U. Volterra has set up and completed the plant of the Cia. Alberto Molho Metales Preciosos in Buenos Aires and is back with the Metals and Controls Corp., Attleboro, Mass., in charge of refining operations.

Edward M. Wallace has formed a company, the Wallace Mfg. Co. in West Springfield, Mass., for the purpose of manufacturing and selling hand shears and allied products.

John P. Warner has completed his period at Kerr-Addison Gold Mines Ltd. under the Ontario Mining Association's postgraduate scheme and now has a permanent post with Falconbridge Nickel Mines Ltd. as a junior engineer in the metallurgical department.

Jonathan M. Whitmer has been working at the International Nickel Co. research laboratory, Bayonne, N. J., since his graduation from the University of Kentucky.

William F. Zerbe is vice-president in charge of operations, a newly created post of the Central Iron and Steel Co., Harrisburg, Pa., subsidiary of Barium Steel. He had been general manager of operations.

—In Petroleum Circles—

Walter K. Arbuckle has a job with the British American Oil Producing Co. as a petroleum engineer trainee. He receives mail at P. O. Box 65, Taft, Texas.

Robert M. Beatty is manager of the geological division of the American Republics Corp. at Houston, Texas.

Stanley A. Bloch is a special instructor in petroleum engineering at the University of Oklahoma, Norman.

Chester U. Burk is a mechanical engineer in the Oklahoma-Kansas division of the Continental Oil Co., Ponca City, Okla.

Robert H. Burns, formerly with the Knowlton Engineering Co., is an independent consultant on petroleum development and production in Oklahoma City, Okla.

J. R. Chestnolvick is with the Continental Oil Co., Fair Bldg., Fort Worth, Texas.

Arthur E. Creamer has the job of petroleum engineer trainee with the Gulf Oil Corp. production division. His mail goes to 1308 2nd St., Rosenberg, Texas.

L. Dean, Jr., is a junior engineer with the Pantepec Oil Co., El Roble Office, Apartado 888, Caracas, Venezuela.

Gustav Egloff, director of research for the Universal Oil Products Co., Chicago, has been elected president of the Western Society of Engineers.

H. B. Fuqua has changed his work and address from the Gulf Oil Corp., Houston, to the Texas Pacific Coal and Oil Co., Fort Worth 1, Texas.

Page O. Greene is working as an engineer for the General American Oil Co. of Texas in Odessa.

John W. Gregg is an assistant professor at the University of Alberta, Edmonton, Alta.

Brooks Hall has been transferred to Billings, Mont., to help open a new office for the Stanolind Oil and Gas Co. there.

J. M. Hansell has transferred to Calgary, Alta., as chief geologist for the Canadian division of the Sun Oil Co.

Bob T. H. Hulsey is a member of the petroleum department of the Chase National Bank, New York City.

J. B. Jones has transferred from Corpus Christi to San Antonio, Texas, to open a new office for the Halliburton Oil Well Cementing Co.

J. Pat Kidd, after graduation from the University of Oklahoma last January, began working for the Delta Drilling Co. He can be reached in care of the Company, Box 2012, Tyler, Texas.

Joseph L. Krieg recently graduated from Texas Tech and is now employed by the Transcontinental Gas Pipe Line Corp. as a progress engineer.

R. A. Legeron has been transferred by the Schlumberger Well Surveying Corp. from Houston to Calgary, Alta., where he will be Canada area manager.

J. J. Zorichak

J. J. Zorichak resumed the chairmanship of the Rangely Engineering Committee on July 15, after a year with the API Dallas office. During the war he served with the PAW, and prior to that was with Stanolind in Tulsa.

K. G. Mackenzie, assistant to vice-president of The Texas Co., was awarded a certificate of appreciation by the API at a dinner of the group's refining division in Houston.

Mahlon F. Manville is employed by the Sinclair Oil and Gas Co. He had worked for that company while attending L.S.U., from which he graduated last June.

Thomas J. McCroden received his Master of Science degree in geology at Stanford in September and took employment as a geologist in the exploration department of the Standard Oil Co. of California, San Francisco.

John A. McCutchin can now be addressed in care of the Bay Petroleum Corp., 308 8th Ave. W., Calgary, Alta.

John R. McKay is now addressed at the British American Oil Co., 209 6th Ave. W., Calgary, Alta.

Jim W. Mims, who graduated from Texas A&M in June, is now employed as a field engineer with the North Basin Pools Engineering Committee

of Midland, Texas. His present residence is Denver City, Texas.

James D. Murdoch, Jr., is development and production engineer for Major Distributors Ltd., Edmonton, Alta.

Oscar C. Person is with the Magnolia Petroleum Co. at Lake Charles, La., as a petroleum engineer trainee.

George K. Peters, after graduating from the University of Pittsburgh with a B.S. in petroleum engineering in June, was employed by the Honolulu Oil Corp. in Taft, Calif., as an engineer in training.

L. Merrill Rasmussen can be reached at Box 11, Seminole, Okla. He is a student engineer with the Gulf Oil Corp.

R. J. Schneider is working with the Hughes Tool Co. in the Rocky Mountain division, stationed at Vernal, Utah. He is field man in northwest Colorado and northern Utah.

Robert R. Shaffer, who recently graduated from the University of Southern California after earning his B.S. degree in petroleum engineering, is employed by the Stanolind Oil and Gas Co. in Levelland, Texas.

Robert C. Shields is working for The Texas Co., 1115 Milburn, Odessa, Texas, as a petroleum engineer trainee.

Warren A. Sinsheimer, Jr., has the job of petroleum engineer with DeGolyer & MacNaughton, consulting petroleum engineers of Dallas.

S. Anthony Stanin received a B.S. degree in geology from the University of Utah in June and took employment with the Phillips Petroleum Co. He is at present a trainee with a seismograph unit in Wyoming, where he is addressed in care of the Company, Box 422, Lander.

Paul D. Torrey became president of Lynes, Inc., a little over a year ago and has gradually discontinued his consulting work. Lynes, Inc., is engaged in the design and development of new tools for selective chemical treatment of oil and gas wells, and for the precise control of the injection and production of fluids from wells. He devotes a good deal of his time to the application of the Company's equipment to gas-oil ratio control, for the exclusion of water, and in secondary recovery and pressure maintenance operations. A new office and plant was recently opened at 7042 Long Drive, Houston.

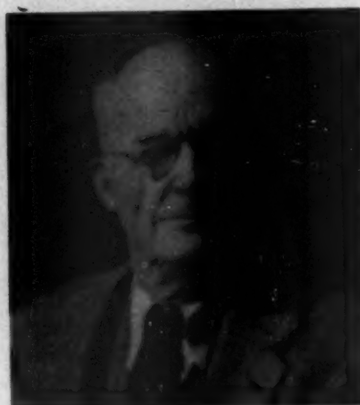
William J. Turner is working in Dallas, Texas, as a junior engineer with the Atlantic Refining Co.

Harold G. Vanhorn received a M.S. degree from Texas A&M in September. He is employed by the Shell Oil Co. as a junior exploitation engineer in the New Orleans area.

Richard H. Widmyer is a petroleum engineer trainee with The Texas Co. at New Iberia, La.

Trevor G. Williams is assistant production engineer for the Anglo-Iranian Oil Co., Abadan, S. Iran.

Obituaries



H. Norton Johnson

H. Norton Johnson (Member 1919), a geologist who had worked in New Zealand and the Philippines as well as in the States, died July 26 at his home in Santa Barbara, Calif. He was professor of geology at Westmont College at the time of his death and was considering an offer by the Afghanistan Government to head a department of geology and mining in a school that government plans to open. Dr. Johnson received degrees from Amherst, Columbia, and Harvard, the latter a doctorate in 1932. He worked for Anaconda and the U. S. Forest Service and then, in 1910, went to New Zealand to find a lost vein of gold. This venture was successful and he became general superintendent of the Consolidated Gold Fields of New Zealand. He returned to the States to work for Phelps Dodge, U. S. Smelting, General Petroleum Corp., and the Metropolitan Water District, then went to the Philippines for the National Development Co., returning in 1940.

Charles Tyndale Evans (Member 1919), chief metallurgist for the Elliott Co., died May 13, 1949. Born at Glen Moore, Pa., in 1872, he studied at Dickinson College, University of Pennsylvania, and Harvard. For twenty years he taught school and then in 1918 switched to the industrial field as chief metallurgist of the Cyclops Steel Co. in Titusville, Pa. By 1936 he was vice-president of the Universal-Cyclops Steel Corp.

Dwight Hugh Fortine (Member 1938), chief geologist for the California division of the Barnsdall Oil Co., died on Aug. 3. His death came at the age of 44 and followed the death of his wife Alice by two days. After receiving his A.B. degree from Stanford in 1926, he went to work for the Miley Exploration Co. as assistant petroleum engineer. He spent three years in Venezuela as exploration geologist for the Caribbean Petroleum Co., returning to California in 1931 to enter the employ of the Barnsdall Oil Co.

Thomas J. Barbour (Member 1897), consulting engineer of San Francisco, is dead. For many years he was president of the Barbour Chemical Works. In the 1920's he opened a consulting office in San Francisco.

Russell Johnson Parker

An Appreciation by Anton Gray

Russell Parker (Member 1944) died Sept. 9 in the crash of a Quebec Airlines plane that took the lives of two other Kennecott officers. Russell Johnson Parker was born in Olney Springs, Colo., and received his education in mining engineering at the Colorado School of Mines, graduating in 1919. Shortly after leaving the School of Mines, he went to the Belgian Congo. There he was engaged in diamond prospecting and production for the Foretminiere.

About 1925, Mr. Parker became interested in the copper possibilities of Northern Rhodesia, about which very little was known at that time. He went to London, joined A. Chester Beatty in the Selection Trust, Ltd., and was associated with that group until he came to the United States in 1940. While with the Selection Trust he examined for them the copper prospects of Rhodesia, and it is almost wholly due to his recognition of the possibilities of these deposits that led the Selection Trust to undertake the developments which resulted in the successful operations now known as the Roan-Antelope and Mufulira mines.

Shortly before the war, Mr. Parker

Necrology

Date Elected	Name	Date of Death
1937	Army Adams	Aug. 20, 1949
1940	Ralph M. Bowman	June 18, 1949
1946	George F. Campbell	June 18, 1949
1944	H. M. Faust	Sept. 19, 1949
1903	Herbert C. Greer	August, 1948
1919	H. Norton Johnson	July 26, 1949
1917	James D. Jones	Unknown
1930	J. H. G. Monypenny	1949
1921	Sydney L. Palmer	May 9, 1949
1916	Rudolph Porter	July 10, 1949
1926	Arthur M. Robinson	June 27, 1948
1938	Joseph M. Thiel	July 16, 1949
1937	Joseph A. Tennant	Unknown
1918	John E. Thomas	Aug. 20, 1949
1914	Arno S. Winther	Unknown
1918	Fred L. Wolf	Sept. 27, 1949
1936	Joseph C. Yob	Feb. 18, 1949

Russell J. Parker

Earl T. Stannard

Arthur D. Storke

was made managing director of the Consolidated African Selection Trust, and he left his position in 1940 to come to the Kennecott Copper Corp. as assistant to the president. In 1948 he was made a vice-president of Kennecott, and put in charge of the Canadian titanium development.

Russell Parker's achievements in his profession, as indicated in this very brief outline, were many, but his greatest achievements were not technical. In Africa, in London, in Colorado, and in New York all the people with whom he worked became and remained his friends. The greatest tribute that has been or can be paid him is the inquiry that has been made wherever he has worked, "When is Parker coming back?"

Earl Tappan Stannard

AN APPRECIATION BY C. T. ULRICH

Earl Stannard (Member 1920) was killed Sept. 9 in the crash of a Quebec Airways plane. Earl Tappan Stannard was born in 1882 at Chittenango, N. Y. He attended the Sheffield Scientific School at Yale and graduated in 1905 in the mining course. He then continued for one additional year in the graduate school.

His first experience after leaving Yale was with the Federal Lead Co. in Missouri. In 1911 he was employed by the Braden Copper Co. in Chile and for three years was general superintendent of concentrators and, as such, was in charge of both construction and operation of the mills.

In 1914 he left Chile for Alaska, subsequently becoming manager of both the Kennecott and Latouche properties of the Kennecott Copper Corp., with general supervision over the railroad which served the mines at Kennecott.

In 1920 he went to Seattle as general manager of the Kennecott properties located in Alaska, of the Alaska Steamship Co., and of the Copper River and Northwestern Railway Co. In 1923 Mr. Stannard was made vice-president of the Kennecott Copper Corp. and in 1929 he moved to New York where he also became vice-president of Braden Copper Co. and of other subsidiaries. In May, 1933, Mr. Stannard was elected president of Kennecott and Braden and continued in these positions until the day of his death. He was also, for a number of years, a director of J. P. Morgan & Co. and the Johns-Manville Corp.

In 1936 an honorary degree of Doctor of Engineering was conferred upon him by the Michigan College of Mining and Technology. In 1937 the King of Belgium named him a Commander of the Order de la Couronne.

Endowed with a keen mind and sound business judgment, he was also possessed of the highest principles and a gracious and charming personality. A man of great energy and capacity for work, he gave unsparingly of his time and efforts. All these admirable qualities combined to make him a wise and effective leader of the Corporation and an outstanding personality in the industry, not only in the United States and Chile, but throughout the world.

Arthur D. Storke

AN APPRECIATION BY FRED SEARLS, JR.

Arthur D. Storke died Sept. 9 in the Quebec Airways tragedy that took the lives of 22 other persons, including two of his colleagues, officers of the Kennecott Copper Corp.

Arthur Storke was born at Auburn, N. Y., May 21, 1894. He attended Leland Stanford in 1913, and the University of Colorado in 1914 and 1915.

In 1916, he entered the employ of Climax Molybdenum and in 1917 became assistant superintendent. The rigors of the Climax location impaired his health and the American Metal Co., which even at this early date appreciated his character and ability, was glad to transfer him to Joplin as its local representative.

In 1918, he enlisted in the 27th Engineers, an exceptional regiment of army troops formed, like the British tunneling companies, for mine warfare and combat shelter construction.

On demobilization, Storke worked out of San Francisco as an independent engineer and, with Carl O. Lindberg and others, on the examination and management of properties from Central America to Alaska until the end of 1925. In 1926, Climax having re-opened in 1925, he returned to that operation as general superintendent. There he not only made prompt improvement in the mining methods, but initiated development work that in 1927 led to the discovery of the present large orebody. In that year, he was again transferred to the American Metal Co., and proceeded to Africa, as assistant to H. S. Munroe.

His confirmation of the favorable opinion of the Rhodesian copper belt in sedimentary rocks, held in early 1928 by few American engineers, other than Parker, Sussman, and one or two more, insured participation by the American Metal Co. in the financing of Roan Antelope and the projects that later were included in Rhodesian Selection Trust.

Storke's part in bringing into production the Roan and Mufulira properties during 1929 and the dark days that followed it, are well known to the mining fraternity on both sides of the Atlantic; but perhaps only the relatively few remaining American engineers, who were involved in these and the contemporaneous efforts at Rhokana, can fully realize the problems—not only of mining methods and metallurgy, but also of native labor, personnel from three nations, colonial government relations, and distance from base, with which the early stages of these developments had to struggle. As D. D. Irwin writes, his success was "a tribute to personality, tact, all-around ability, and good judgment." His energy and capacity are evidenced by the fact that before these operations were in full swing, Storke also functioned as managing director of Selection Trust, controlling the management of the totally different operations of Trepca and Beatty's alluvial diamond mines.

Storke's services to England, his adopted country, during the recent war will probably never be fully known for much of it was in Air Force intelligence; but it is fair to say that his work as mineral adviser to the Ministry of Supply was outstanding and, of itself, well merited his decoration as C.M.G. by the King in 1947 "for mining development in the Colonial Empire."

It is perhaps less generally known that Storke's early recognition of the possibilities of the O'okiep District and, particularly, his more recent vigorous espousal of the purchase and unwatering of the Tsumeb property in South West Africa, had much to do with the success of these enterprises.

However, this is an appreciation, not a biography. Kennecott has lost the services of a man who would have upheld its leadership and its traditions, and carried them further; and as future services are worth most in the future, Kennecott has lost the most. But it is perhaps we in the Metal Company and Newmont, who have known Storke longer, who have been in the past, and recently, beneficiaries of his initiative, ability, and judgment, who have sat with him as directors and friends, and worked with him on common problems—it is perhaps we who will most miss his cheery smile and his quiet words of wisdom and good sense. God give him the rest he has earned.

Arthur Michael Robinson (Member 1926), mining consultant whose work had taken him all over the globe, died in England on June 27, 1948. He was born at Clitheroe, England, in 1892. The first World War interrupted his studies at the Royal School of Mines but he received his degree in 1920. His first mining job was in Ireland; then he returned to London to work for the Palmer Foundry and Engineering Co. and later for the "SG" Minerals Syndicate Ltd. In 1924 he went to Par Treves, France, as chief surveyor to the Mines de Villemagne. In the 1930's he worked for Mount Isa Mines, New Guinea Goldfields and Gold Coast Banket Areas Ltd. and since then had done consulting work.

Alfred Clark Stoddard (Member 1917), chief mining engineer for the Inspiration Consolidated Copper Co., died on July 15. He joined the Inspiration staff in 1912 and worked for the Company until his death. Born at Denver in 1879, he received his M.E. degree from the Michigan College of Mines. He had worked for the O.D. Copper Mining and Smelting Co. and the New York and Honduras Rosario Mining Co.

Joseph A. Tennant (Member 1937), president of the Tennant Co. of Houston, is dead. After receiving his B.A. degree from the University of Texas and his S.B. degree from MIT, he became industrial engineer for the Rochester Railway and Light Co. After a year as consulting city engineer for Houston, he became president of the consulting engineering concern that bore his name. He was also vice-president of the Abercrombie Pump Co. and the Rio Grande Eastern Railway Co.

Joseph Mathias Thiel (Member 1938), mining geologist, died at Joplin, Mo., on July 16, 1949, following several months' illness. He was born in St. Paul, Minn., on March 3, 1899, and was a graduate of the University of Minnesota School of Geology. Practically all of his professional career was spent in the Central States, first with the Wisconsin Geological Survey, then for nearly ten years, beginning in 1920, with the Missouri Geological Survey where he was in charge of its Joplin branch. He then worked with the U. S. Geological Survey for nearly two years. In 1935, Mr. Thiel joined the geological staff of George M. Fowler, Consulting Geologist, where he was employed continuously until his death. The excellence of Mr. Thiel's work is attested in many maps and other data that were published by the Missouri Geological Survey and in thousands of his recorded observations pertaining to the stratigraphy of the Tri-State mining district.

John Elmer Thomas (Member 1918), widely known oil man and geologist, died Aug. 20 in Fort Worth, Texas. He had returned only recently from Italy where he investigated the oil reserve of the Po Valley for the Italian Government. Mr. Thomas, a native of Ohio, began his career, after graduating from the University of Chicago, with AS&R. He served as geologist for several oil companies and in 1917 went into consulting work. He was a member of the volunteer committee on petroleum economics for the Federal Oil Conservation Board and later was associate chief of the fuel section of the OPA. He also served as special assistant to the deputy petroleum co-ordinator.

Charles Erb Wuensch

AN APPRECIATION BY
PHILIP J. MCGUIRE

Charles Erb Wuensch, familiarly known as "Erb" to his many and widely distributed friends throughout the Western mining world, died Aug. 27 in San Francisco. In his 57 years he firmly established his ability as an inventor and an engineer. He was always eager to help anyone in need and his friendliness and generosity will be greatly missed by all who knew him.

Mr. Wuensch received an E.M. degree from Colorado School of Mines in 1914 where he participated in athletics and showed early technical talent. After two years' experience with Empire Zinc, he went to Central America for a year on geological work. Subsequent engagements were with Thane Exploration Co., American Smelting & Refining, U. S. Smelting, and consulting work up to 1927.

Locating then in Joplin, Mr. Wuensch became so interested in making the Missouri-Kansas Zinc Corp. a success that he developed the differential density (heavy media) sink float process that has since come into wide general use.

The move from Joplin, Mo., to San Francisco was made about 1940. Since then, consulting work in mining and metallurgy in the United States, Mexico, and Central America took up part of his time. However, the primary interest throughout the life of Mr. Wuensch was invention, which he pursued with tremendous energy along many lines. Besides the sink float process mentioned above which is at present his best known development, his inventive mind covered a wide range of ideas. He also contributed technical articles for publication to advance the development and general knowledge on many of the above subjects.

The mining industry will miss his untiring energy and inventive enthusiasm and his friends will miss even more the man himself, sociable, kindly and generous.

Proposed for Membership

Total AIME membership on Sept. 30, 1949, was 15,988; in addition 4427 Student Associates were enrolled.

ADMISSIONS COMMITTEE

James L. Head, Chairman; Albert J. Phillips, Vice-Chairman; George B. Corless, T. B. Counselman, Ivan A. Given, Robert L. Hallett, Richard D. Mollison, and John Sherman.

Institute members are urged to review this list as soon as the issue is received and immediately to wire the Secretary's Office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; AM, Associate Member; S, Student Associate; F, Junior Foreign Affiliate.

ARIZONA

Ajo — PAPKE, KEITH GEORGE. (C/S—S-J). Assistant engineer, Phelps Dodge Corp.
Hayden—OWEN, JOHN WILLIAM. (C/S—S-J). Junior engineer, Kennecott Copper Corp.
Morenci — ALEXANDER, ALBERT LEONARD. (C/S—S-J). Assistant shift foreman, Phelps Dodge Corp.
Superior—PETERSON, ROY ERNEST. (C/S—S-J). Trainee, Magma Copper Co.

ARKANSAS

Malvern—ALLEN, ROBERT ALVA, JR. (J). Mineralogist, Baroid Sales Division, National Lead Co.
State College — KEETON, JOHN RICHARD. (C/S—S-J). Engineering instructor, Arkansas State College.

CALIFORNIA

Alhambra — ALLINDER, WILLIAM FREDERICK. (C/S—S-J). Petroleum engineer, Seaboard Oil Co. of Delaware.
Altadena — SLATTERY, HARRY WILLIAM. (J). Engineer, Oil Properties Consultants.
Bakersfield—ARMBRUSTER, EARL AUGUST. (M). Division exploitation engineer, Shell Oil Co. BETHEL, FRANKLIN THOMAS. (C/S—S-J). Senior core analyst, Superior Oil Co.
Bellflower — FULLERTON, HAL BRADFORD, JR. (C/S—S-J). Engineer in training, The Texas Co.
Concord—VOGT, WILLIAM A. (M). Project engineer, Kaiser Engineering, Inc.
Hollywood—RIEGLE, JOHN, JR. (M). Petroleum engineer, Southern California Gas Co.
Long Beach—KEALER, RAYMOND CHESTER. (M). Self employed. VOGEL, LEE CHARLES. (J). Chemist. Oil Well Research, Inc.
Montrose—WHITLOCK, REGINALD RAY. (C/S—S-J).
Playa Del Rey—GRANER, JESSE BLAINE. (C/S—S-J). Petroleum engineer, Graner Oil Co.
San Francisco — WEBER, MARY HILL. (J). Mining geologic aid, California Division of Mines.
San Leandro — LAMBERT, EARL FREEMAN. (C/S—S-J). Assistant geologist, San Luis Mining Co.
South Gate — EDSON, THOMAS FARRER. (M). Executive vice-president, A. R. Mass Chemical Co.
Walnut Creek—BRUTON, WILLIAM CHARLTON. (AM). District sales manager, American Manganese Steel Division, American Brake Shoe Co.
Whittier—ATKINS, EARLE RICHARDSON, JR. (J.) Associate production engineer, Union Oil Co. of California. MONROE, REX. (C/S—J-M). District sales manager, refinery division, Sivyer Steel Casting Co. PRESTON, FLOYD W. (C/S—S-J). Assistant research engineer, California Research Corp.

COLORADO

Climax—LEINON, CLYDE HENRY. (C/S—S-J). Engineer, Climax Molybdenum Co.
Denver—RITTER, ETIENNE ALPHONSE. (R—M). Mining engineer, Cripple Creek Mines.
Durango—ROBERTS, DAVID. (C/S—J-M). Major, Corps of Engineers, U. S. Army.
Golden — SINHA, BINDESHWARI NARAIN. (AM). Assistant geologist, Geological Survey of India.
Ouray—HALLOCK, JOHN ROBERT. (C/S—S-J). Mill helper, Idarado Mining Co. TAYLOR, I. ROBERT. (C/S—S-J). Sampler, Idarado Mining Co.

CONNECTICUT

Bridgeport—STEVENS, MARSHALL WILLIAM. (C/S—S-AM). Foundry metallurgical engineer, General Electric Co.
Greenwich—STARR, H. DANFORTH. (AM). Assistant to president, Cerro de Pasco Copper Corp.
Plymouth—TROUT, DELMAR EVERETT. (C/S—S-J). Metallurgist, Scovill Mfg. Co.
Stamford—WARK, CARLOS RICHARD. (C/S—J-M). Metallurgical engineer, American Cyanimid Co.

DISTRICT OF COLUMBIA

Washington — ONODA, KIYOKO. (C/S—S-J). Mineralogist, U. S. Geological Survey.

FLORIDA

Plant City — CATHCART, JAMES BACHELDER. (C/S—J-M). Geologist, project chief, Florida phosphate, U. S. Geological Survey.

GEORGIA

Gainesville — CASTLEBERRY, DOUGLAS. (C/S—S-J).

IDAHO

Kellogg—LOMAS, RAYMOND EDWARD. (M). Mine superintendent, Sunset Minerals, Inc.

ILLINOIS

Alton—HASEMEYER, EARL ALBERT. (C/S — S-J). Metallurgist, Western Cartridge Co.
Chicago—ELLIS, JOSEPH MATTHEW. (C/S—S-J). Equipment test engineer, Ingersoll-Rand Co. FREY, E. LEE, JR. (C/S—S-J). Plant metallurgist, micro-cast division, Austenal Laboratories. GLASSER, JULIAN. (M). Research metallurgist, Armour Research Foundation. HEIKKINEN, LILIAN MAY. (C/S—S-J). Laboratory technician, Institute for the Study of Metals, University of Chicago.
Chicago Heights—SHUBERT, FRANCIS LAWRENCE. (C/S — S-J). Metallurgist, Combustion Engineering-Superheater, Inc.
Elmhurst—FOOTE, FRANK G. (C/S—J-M). Division director, Argonne National Laboratory.
Galena—DALE, CLAUDE OLIVER. (C/S—J-M). Mining engineer, Eagle Picher Mining and Smelting Co.

INDIANA

Bloomington — BARUA, VICTOR FELIX. (J). Assistant geologist, Ground Hog unit, American Smelting and Refining Co.
Crown Point — GORSKI, RICHARD ALFRED. (C/S—S-J). Foreman relief trainee, Carnegie-Illinois Steel Corp.
East Chicago—BARRETT, DONALD J. (J). Mill trainee, Inland Steel Co.
Gary — MICKELSON, CEDRIC GROPPER. (C/S—J-M). Research metallurgist, American Steel Foundries.
Hammond—MORTON, RAYMOND LEWIS. (C/S—S-J). Staff assistant, blast furnace, Wisconsin Steel Works, International Harvester Co.
Indianapolis — SHERWOOD, SAMUEL FERGUSON. (AM). Assistant to the president, Central Indiana Coal Co.
Linton — DUKES, WILLIAM WEAVER. (M). Design engineer, Central Indiana Coal Co. and Sherwood-Templeton Coal Co.
Whiting—BAUMANN, GEORGE M. (C/S—J-M). Assistant to the manager, Federated Metals division, American Smelting and Refining Co.

IOWA

Fort Dodge—HARVEY, ALFRED S. (C/S—S-J). Chief of party, Glenn H. Miller.

KANSAS

Eureka—HAUGH, WENDELL JOE. (M). District engineer, Tidewater Associated Oil Co.
Great Bend—TERRY, LOUIS LYMAN. (R, C/S—S-M). Electric pilot engineer, Dowell Incorporated.
Holyrood — HARRY, EDWARD BROOKE, JR. (C/S—S-J). Engineer trainee, Sohio Petroleum Co.
Hutchinson—COSHOW, ROBERT G. (C/S — S-J). Production engineer, Skelly Oil Co.
Sunflower — CASSIDA, WALTER. (C/S—S-J). Core drill supervisor, Continental Oil Co.
Wichita — DICKEY, LEONARD CLAUDE. (C/S — S-M). Petroleum engineer, U. S. Air Force. SPRINGER, FREDERICK MICHAEL. (C/S—S-J).

KENTUCKY

Henderson—CHARLEY, THEODORE EUGENE. (C/S—J-M).

LOUISIANA

Grand Isle — TRUBY, LESTER GEORGE, JR. (C/S—S-J). Junior petroleum engineer, Humble Oil and Refining Co.

Jefferson Parrish — HANSEN, CHRISTIAN ANDREAS, JR. (J). Junior petroleum engineer, Humble Oil and Refining Co.

Lafayette—AULICK, BURTON WILSON. (M). Division engineer, Halliburton Oil Well Cementing Co.

Monroe—BROWN, KERMIT EARL. (C/S—S-J). Junior petroleum engineer, Stanolind Oil and Gas Co.

Shreveport — CRAIG, WILLIAM LAIRD. (C/S—J-M). Production engineer, Arkansas Louisiana Gas Co. FOWLER, HENRY FLOREY. (C/S—J-M). Chief zone geologist, Gulf Refining Co.

MARYLAND

Sparrows Point—STOTT, CHARLES T. (C/S—J-M). Test engineer, Bethlehem Steel Co.

University Park — PANEK, LOUIS ANTHONY. (C/S—J-M). Roof control research engineer, Bureau of Mines.

MASSACHUSETTS

Belmont—OBERG, FRED NELSON. (C/S—J-M). Research engineer, Division of Industrial Co-operation, MIT.

Westboro—JOHNSON, CARL GUNNARD. (M). Associate professor, Worcester Polytechnic Institute; vice-president, Presmet Corp.

MICHIGAN

Dearborn—THOMAS, JOHN MARION. (C/S—S-J). Metallurgical engineer, Hoskins Mfg. Co.

Detroit—PRAKKEN, JOHN COOK. (C/S — S-J). Plant metallurgist, Chrysler Corp.

Pontiac — HEID, WILLIAM KENNEDY. (C/S—S-J). Foreman, Pontiac division, General Motors Corp.

Ypsilanti — RAYNOR, CLARENCE LeROY. (C/S—J-M). Metallurgical supervisor, Hoskins Mfg. Co.

MINNESOTA

Duluth—MIELKE, MORRIS VERNE. (C/S—J-M). Assistant concentration engineer, Oliver Iron Mining Co.

Hibbing—SUDASNA, PISOOT. (C/S—S-J). Mining engineer, Hibbing-Chisholm district, Oliver Iron Mining Co.

Minneapolis—DeMONEY, FRED W. (J). Instructor, University of Minnesota.

Nashwauk — VIANT, MELVIN LeROY. (C/S—S-M). Mine engineer, Cleveland Cliffs Iron Co.

St. Paul — BECK, WARREN RANDALL. (M). Section leader, Minnesota Mining and Mfg. Co.

Virginia — WEILER, CHARLES T. (C/S—J-M). Industrial engineer, Inter-State Iron Co.

Winona—BROM, LEO JOHN (C/S—J-M). Metallurgist, Brom Machine and Foundry Co.

MISSOURI

Annapolis—SUTTON, GLEN WOOD. (J). Industrial engineer, Tennessee Coal, Iron and Railroad Co.

Bonne Terre — PETERSEN, KENNETH CHARLES. (J). Surveyor, St. Joseph Lead Co.

Desloge — HARTER, WARREN FRANCIS. (C/S—S-J). Surveyor, St. Joseph Lead Co.

Flat River — SORKIN, JEROME HERBERT. (C/S—S-J). Surveyor, St. Joseph Lead Co.

Fulton—ANDERSON, GEORGE McCRAE. (C/S—S-J). Mining engineer, Harbison-Walker Refractories Co.

Kirkwood — FASER, JACK FRED. (R, C/S—S-J). Sales engineer, Ingersoll-Rand Co.

Overland — MOULTON, BERNARR GAMMILL. (R, C/S-J-M). Sales engineer, Ingersoll-Rand Co.

Potosi—CHANEY, JAMES BYRON. (C/S—S-J). Engineer, Baroid Sales Division, National Lead Co.

Rivermines — McHENRY, L. CHARLES. (C/S — S-J). Engineer, Tennessee Coal, Iron and Railroad Co. WAGNER, RICHARD EDWIN. (R—M). Geologist, St. Joseph Lead Co.

Rolla—HASKELL, DONALD FORREST. (C/S—S-J).

St. Louis—GEHLSEN, REIMER G. (M). Sales manager, Joy Mfg. Co.

Sedalia—QUINN, JOSEPH S. (C/S—S-J). Engineer in training, Allis-Chalmers Mfg. Co.

Webster Groves — GOSEN, JOHN WILLIAM. (C/S—S-J).

MONTANA

Butte—SIMPKINS, GEORGE ROBERT. (C/S—S-J). Assistant mining engineer, Anaconda Copper Mining Co.

Cut Bank—LADD, J. BERTRAM. (C/S — S-J). Petroleum engineer trainee, The Texas Co.

Great Falls — ALF, ALFRED IMMANUEL. (R, C/S—JA-M). Superintendent, zinc electrolyzing and cadmium departments, Anaconda Copper Mining Co. GRAHAM, THOMAS KENNEDY. (M). Assistant superintendent of zinc plant, Anaconda Copper Mining Co. JACKSON, MERYL ARTHUR. (M). Chief chemist, Anaconda Copper Mining Co. SMITH, JAMES FRANCIS. (R, C/S—JA-M). Assistant superintendent, copper refineries, Anaconda Copper Mining Co. WEVER. GUY THOMAS. (M). Superintendent of indium and rare materials department, Anaconda Copper Mining Co.

NEVADA

Reno—WELLS, ROBERT LEWELLYN. (J).

Searchlight—MOORE, FRANK CHARLES. (C/S — S-J). Engineer, Searchlight Homestake Mining Co.

NEW JERSEY

Franklin — ANTONIDES, LLOYD EARL. (C/S—S-J). Level boss, New Jersey Zinc Co.

Newark — ROSTOSKY, ANDREW, JR. (C/S—J-M). District manager, Mechanization, Inc.

Rahway—MILLER, MARTIN STANLEY. (C/S—S-J). Research metallurgist, Crucible Steel Co. of America.

NEW MEXICO

Albuquerque—BRADISH, BEVERLY B. (C/S—J-M). District geologist, Skelly Oil Co.

Carlsbad—GALE, CARLOS. (C/S—AM-M). Granular plant foreman, U. S. Potash Co.

Eunice—JAMES ROBERT KING. (C/S — S-J). Petroleum engineer trainee, Magnolia Petroleum Co.

Silver City—WHITE, ATHINGTON. (R, C/S—JA-M). Chief engineer, American Smelting and Refining Co.

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Mining Potash Ores in Carlsbad Area

By RUSSELL G. HAWORTH,* Member AIME

Introduction

Three companies, United States Potash Company, Potash Company of America, and International Minerals and Chemical Corporation, are now operating potash mines and refineries in the Carlsbad, New Mexico, area. The three mines are located approximately twenty miles east of Carlsbad. The deposits have been found ideal for mechanized mining methods. This summary has been compiled from information made available by the three operating companies.

Prospecting

Since outcrops of potash are nonexistent, prospecting is accomplished by drilling and coring of the salt section to establish the grade, thickness, and outline of the potash beds contained in the salt deposits. Information regarding the nature of the formations in the cover of 400 to 600 ft thick over the salt and potash beds is also obtained from drill cuttings in the same operation. By proper interpretation of assembled data the best location for shafts may be determined.

The overburden varies in character but consists in general of interbedded shales, sand, gravels, limestones, and anhydrite beds. Water, in unpleasant quantities, especially in the sands and limestones, often completes the geologic section. Some of the shafts in the area have been sunk without undue difficulties, others have been delayed by flows of water. Most of the shafts are concreted from the surface to the salt section. Each of the three mines in the Carlsbad area has one shaft for hoisting ore and one for hoisting men and supplies.

Mining Methods

Information acquired from initial drilling and prospecting affected the choice of mining methods. Since the tabular, slightly rolling deposits were similar to coal seams, the room-and-pillar system used in coal mining was adopted by all the companies. Pillars have not been removed in any of the mines on a large scale. One company has conducted experimental robbing of pillars in one restricted area. Where it is known that overlying strata contain water in large amounts, it is not considered practical to risk flooding of the mines by removing pillars without fill. Some thought is now being directed toward development of economical methods of filling for pillar recovery. The problem is not identical at the three mines and local conditions will govern the methods employed for eventual pillar recovery. The important point is that, with large reserves, it has not been necessary to resort to mining of pillars for adequate production.

The ore deposits are laterally extensive but are irregular in shape and lie at a depth of 700 to 1100 ft below the surface. The major operations of all mines are on the same bed stratigraphically, except for the langbeinite level at International Minerals and Chemical Corporation. The deposits are apparently not connected and in many parts of the deposits being mined, "salt horses" or barren zones occur. From 400 to 700 ft of salt with minor beds of polyhalite and anhydrite lie immediately above the ore horizon. The ore differs from the salt only in the potassium chloride content and color due to small amounts of iron associated with the sylvite, giving the ore a somewhat mottled red and white cast. Thickness of the ore varies from 5 to 14 ft.

Rooms and break-throughs in the mines vary from 24 to 40 ft in width, the overlying salt forming an excellent roof and providing safe mining conditions. Almost no timber is used in any of the mines for roof support.

Drilling is normally the first step in mining the face of a room. Electric motor driven auger drills are used in the area. Jack hammers were used to some extent when the mines were first opened but the ore is easily drilled if bits are sharp and the coal type

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drills have been used for a number of years. Tungsten carbide tipped drill bits are being introduced now. This type of bit was first used by International Minerals and Chemical Corporation to reduce drilling costs in the harder langbeinite (hydrated potassium-magnesium sulphate) ore which is being mined in one of the upper beds.

Drilling patterns vary but are standardized at each mine. Spacing of holes ranges from 36 to 48 in. on the points of the holes. Drilling speed is 28 in. per min during actual operation.

The second step in face preparation is undercutting of the ore on or near the lower contact of the potash bearing bed. The first undercutter was introduced shortly after mining was begun in an attempt to reduce blasting costs. There are no major cleavage zones in the ore. The beds are a mass of small interlocked crystals with individual cleavages at varying angles. This produces a firm, resilient and cohesive material which is much more difficult to break than might be expected. The additional free face provided by undercutting reduces explosive costs and prevents "boot legging" of holes. Cutter bars are 9 ft in length and rounds from 8 to 8½ ft in depth are broken. The resultant smooth floor is also advantageous for mechanical loading. Cutting speed is usually 6 in. per min across the face and 5 to 6 in. kerf is cut. Shortwall undercutters are used in all three mines. Tire and track mounted universal machines are used in addition to shortwall machines at Potash Company of America.

After the face has been cut and drilled, the holes are loaded and shot with electric primers. Blasting circuits are provided for each section and blasting is done only at the end of the shift. From 0.7 to 0.9 lb of low density explosive per ton is required to break the ore.

LOADING AND HAULAGE EQUIPMENT

Advances in loading and haulage equipment have been made throughout the history of potash mining in Carlsbad. Hand loading into cars was soon replaced by the dragline or scraper loader. If hand loading were used today to handle salt and ore moved underground, over 1000 men would be required for shoveling alone. Two or three drum hoists mounted on a track-type steel loading ramp scraped the ore from the face over the ramp into cars. Track-mounted loading machines were introduced in 1936 and the trackless mining equipment was introduced by International Minerals and Chemical Corp. in 1940. These mobile, caterpillar-mounted loading machines with shuttle cars now are used by all three companies for handling most of the ore.

The loading unit is powered by one or more electric motors with a trailing cable and is mounted on a caterpillar-type truck. The loading head consists of a wide steel frame with a digging arm mounted on each side. The arms are driven by rotating plates and are pivoted on the frame. The arms dig into the pile of broken ore and sweep it on a chain conveyor in the center of the loading head. The chain conveyor operates over a long tail boom and discharges the ore into a shuttle car. The shuttle car is equipped with a chain conveyor in the bed which moves the load back from the end of the car being loaded, to the discharge end. Two or more shuttle cars are used with each loading machine. While one car is hauling ore to the discharge point, others are being loaded, thus obtaining a larger capacity from the loading machine. Discharge of ore from the shuttle cars is normally made into elevating conveyors which discharge into mine cars on a track. Ramps are often used where shuttle cars dump directly into mine cars spotted below the ramp. The shuttle cars are open on one end and the operator, by pressing the proper button, can start the chain conveyor in the bed of the car which discharges the load out the open end.

Shuttle cars range from 4½ to 11-ton capacity. The smaller cars are battery-operated while the largest types are trolley-operated. Some of the latest models are cable reel type. Batteries are designed to operate for one shift. Two sets of batteries are required for each shuttle car, one set being charged during the shift, while the other is in use.

Tracks are located at various intervals, usually parallel to the panel or working face. Maximum shuttle car haul varies from 500 to 1000 ft, depending chiefly on the capacity of the shuttle car being used.

Workings are developed so that mining progresses up-grade, if possible. Miners have known for some time that it is easier to haul down hill than uphill. Shuttle cars are sensitive in this respect also, especially the battery-powered type. Although they will negotiate relatively steep grades, it is not practical to haul ore up such grades except for short distances.

Locomotives and mine cars are of different types and sizes. Car capacity ranges from 4 to 6 tons. Locomotives from 8 to 30 ton tandem are used. Trolley locomotives are in service at all the mines. Some combination battery-trolley types are operating also. The ore is hauled to the shaft where it is dumped into the skip pockets. Rotary dumps are in service at two of the mines while the other uses Granby type cars dumping over a grizzly. The ore is crushed to minus 4 in. underground where rotary dumps are used.

VENTILATION

Ventilation systems differ in detail at the three properties but all use two shafts, one downcast, one upcast with the intake air being restricted to haulage ways from which it is coursed through working sections and return airways to the upcast shaft. One or more fans are installed either underground or on the surface along the circuit.

HOISTING

Hoisting of ore is by skip. Connected horsepower on hoists ranges up to 1000. Skip capacity ranges from approximately 5 to 8½ tons and balanced hoisting is used in each case.

All mine equipment is electrically operated and 220 volt alternating current and 250 volt direct current is used, the latter for trolley locomotives. For distribution to section transformers or motor-generator sets or rectifiers, 2300 volt alternating current is employed.

Summary

It may be noted that the operations and methods closely approximate those of coal mining due in large part to the flat beds. Nothing new has been developed in this field underground except for the adaptation of coal mining equipment to handling of the harder and heavier material. The surface plants would not appear familiar to the coal operator, however. Mining conditions in general are more favorable than most coal or hard rock mines. We are particularly fortunate in that respect. The mine superintendent's problem is no different here, though, from other mines—How to keep the bins from going empty.

A Simple Method for Making Stereoscopic Photographs and Micrographs

By LOUIS MOYD,* Member AIME

Introduction

In the preparation of illustrations to accompany reports of investigations concerning particle shapes of various natural and manufactured materials proposed for use as fine aggretates in concrete structures, it was found that stereoscopic views of such materials presented the information much more effectively than the usual two-dimensional photographs.

With the whole-hearted cooperation of the Photographic Section, a technique was developed in the petrographic laboratory of the Concrete Research Division, U.S. Corps of Engineers, at Clinton, Miss., for simple and rapid preparation of paired stereoscopic photographs and micrographs. The method requires only equipment which is usually part of the general stock of any laboratory, and it is adaptable for all purposes in which three-dimensional views would be found superior to ordinary photographs.

Stereoscopic Photographs

Where the subject or subjects to be photographed are small but not of microscopic size, an ordinary camera having a ground-glass focusing screen is set up vertically over the field. The material to be photographed is placed on a card, the surface of which is suitable as a background. The card is mounted so that it can be tilted about

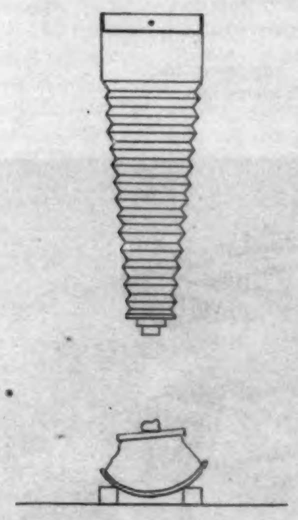

FIG 1—Arrangement of equipment for taking paired stereoscopic photographs.

5° above and below the horizontal plane, on an axis that coincides with the north-south diameter of the viewing screen. A simple way of achieving this is to mount the card on an object having a convex lower surface. In our laboratory, a watch-glass has been used, with plasticene as the mounting medium. The convex surface should be mounted on a support having a round opening on top and a flat bottom. A roll of tape, a petri dish, a beaker, or any other piece of equipment having the proper shape to give stability to the setup will be satisfactory. The arrangement of the required equipment is shown in Fig 1.

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For the best results, the subject to be photographed should be mounted in the plane of the axis of rotation. To achieve this effect, the depth of the mass of plasticene between the background and the watch-glass is varied so that when the watch-glass is tilted back and forth on the axis, the subject to be photographed does not appear to move back and forth across the viewing screen. A permanent piece of equipment, embodying an adjustable vertical screw, with lock-nuts, could be made for this purpose.

The subject may be illuminated in any manner desired. It was found that the presence of shadows intensifies the effect of depth. In taking the photographs, the concave surface is mounted so that one side of the background card is about 5° below the horizontal, while the axis remains in the horizontal plane. The subject is focused carefully on the ground glass and a picture is taken. The card is then tilted so that the opposite side is about 5° below the horizontal, while the axis still remains in the horizontal plane. The subject is again put in focus and another picture is taken. After both pictures are developed and printed, they are placed side by side in the same orientation and examined with a stereoscopic viewer. If depressions appear where there ought

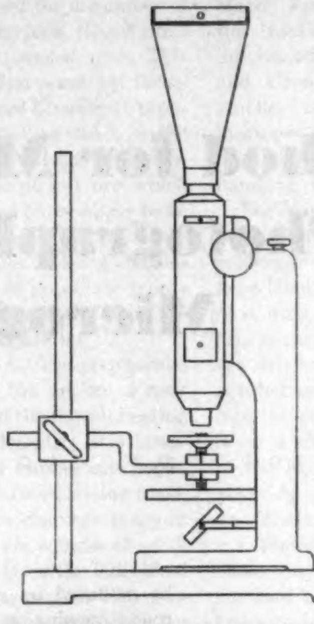

FIG 2—Arrangement of equipment for taking paired stereoscopic micrographs.

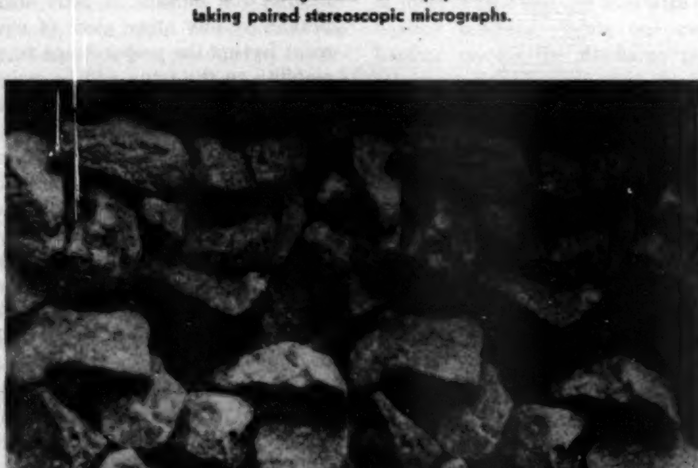

FIG 3—Stereoscopic micrographs showing shape and surface texture of sand manufactured from dolomitic limestone. Particles passed No. 8 and were retained on No. 16 sieves.

to be elevations, then the position of the pictures should be reversed. The finished pairs may be mounted together on cardboard, or the negatives may be trimmed and fastened together so that both views will appear on the same print. The paired photographs obtained by this method are equal in quality to those obtained by the use of special stereoscopic cameras or by use of any of the complex camera accessories made for the same purpose. Some of the commercially made accessories cannot be focused in the short distance required for the photography of small objects.

The procedure outlined above, involving rotation about an axis, may be modified for use with subjects too bulky for the small-scale equipment described.

Stereoscopic Micrographs

The same principle can be used for the preparation of stereoscopic photographs of subjects of microscopic size, with the method modified to meet the requirements of micrography. Any microscope and microscope-camera attachment which can be used for taking ordinary micrographs can also be used for the taking of stereoscopic pairs, and the microscope-camera arrangement is not changed for this work. The lens system should be chosen on the basis of the greatest depth of focus possible for the size of the desired field. Wherever the grain-size of the subject permitted, our laboratory used one "barrel" of a stereoscopic microscope, tilted upright, with a simple microscope-camera having a ground-glass focusing screen, thus insuring a maximum size of field and depth of focus. It is obvious from the description of the equipment used for megascopic subjects, that a universal stage on the microscope would be ideal for mounting the subject for stereoscopic micrographs. However, if a universal stage is not available, a satisfactory substitute may be readily assembled from standard laboratory equipment. Here again, it is necessary to be able to rotate the mounted subject through a range of 5° above and below the horizontal, around an axis which remains horizontal and whose direction coincides with the north-south diameter of the viewing-screen of the camera. A laboratory ring-stand with assorted clamps will satisfy these requirements. The requirement that the subject be located in the plane of the axis of rotation can be satisfied by making some simple device for regulating the elevation of the field. In our laboratory, a piece of copper tubing, bent as shown in Fig 2, was clamped into the ring-stand for this purpose. The end of the tubing was flattened, a hole was drilled through it, and a small nut was soldered on. A small, flat-topped bolt was threaded through the nut and a second nut was added to lock the unit. Specimen mounts were cemented to the top of the bolt.

This simple equipment has proved adequate for the preparation of excellent, paired, stereoscopic micrographs. A typical pair of micrographs taken in this manner is shown in Fig 3. Modifications and refinements of all the above-described equipment will readily suggest themselves to anyone who might be interested in taking stereoscopic photographs by this method.

Acknowledgments

The author appreciates greatly the assistance given him by Miss Mildred Miller and Mr. Frank R. Cuddy, Photographers, Corps of Engineers.

Lightweight Aggregate Industry in Oregon

By N. S. WAGNER,* Member, and R. S. MASON,* Junior Member AIME

Introduction

The production of lightweight aggregates in Oregon is a new industry, and, like all new enterprises, it is suffering from growing pains characterized by numerous, small operations some of which flourish for a short time and then cease altogether. Normally all industrial mineral products are produced in a highly competitive atmosphere. At the present time this condition does not exist to a very marked degree in the state because as yet producers have not saturated the constantly expanding market. This paper has been prepared with the intention of outlining very briefly the current status of the various products now being used as lightweight aggregates in Oregon. The present picture will surely change, perhaps quite radically within even a short space of time.

Lightweight Aggregates Used in the Northwest

PUMICE

Interest in Oregon pumice is not new. Deposits are abundant. Successful development, however, dates only from 1946. During 1948 a total of nine operations was engaged in full or part-time production of aggregate. The postwar building boom and increased public consciousness regarding the value of insulation are the immediate reasons behind the current development. Just how firmly this production of pumice aggregate may be established is something which cannot be foretold at the present time. Much will depend upon how successfully the pumice aggregate construction already installed stands the test of time. Some fine pumice aggregate products have been made and it seems probable that because of its unique properties a certain demand for pumice aggregate will continue in the future. Fire-proof, rodent-proof, decay-resistant properties supplement the lightness in weight and insulation properties of pumice aggregate products in rendering them particularly ideal for many types of construction. In addition there has been fabrication in the form of reinforced fence posts, street markers, and similar products of a specialized-product nature and these are not to be overlooked in terms of future production. Also pertinent to how soundly pumice aggregate production is established will be possible future competition with other lightweight aggregates. However, this situation will be governed largely by competitive costs of production and marketing.

For its present use, which is almost exclusively limited to the manufacturing of building blocks, the market for Oregon pumice aggregate has been extended from the mining area around Bend and Chemult to points as far distant as San Francisco and Seattle. Naturally enough the bulk of the production goes to the Portland and eastern Oregon consumers. Shipments are made by both rail and truck.

Early in 1947 the State Department of Geology and Mineral Industries made a canvass of all pumice producers in the state. The production for 1946 amounted to 26,614 cu yd and was valued at $43,649 at the plants. The United States Bureau of Mines estimates the production for 1947 as 33,240 short tons valued at $111,380. This is roughly 65,000 cu yd. No data are available for the 1948 production but it is understood to exceed that for 1947.

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[1] References are at the end of the paper

The Oregon pumice occurrences originated largely from the eruption of Mount Mazama, the name of the formerly active volcano and the location of Crater Lake. Other lesser volcanoes throughout the area contributed to the present occurrences, however, and it has been estimated by Moore[1] that the pumice deposits cover an area of some 3500 square miles. This area lies east of Crater Lake between Bend and Klamath Falls and embraces the southern portion of Deschutes County, the northern part of Klamath County, and the northwest corner of Lake County. Thickness of the pumice ranges from thin skims to local thicknesses of as much as 30 to 40 ft. Fragment size also varies greatly. Any attempt to describe the situation by giving screen analyses would be confusing because of the wide variations to be found in an area of this size. The picture can best be summed up by stating that places showing great variations in fragment size can be found if a search for extremes is made. For mining purposes in connection with aggregate production, it can be stated that miles and miles of pumice exist in which the fragment sizes range from an inch or so downward.

The usual color of the pumice is a light gray to off-white. A typical pumice analysis shows a silica content of about 69 pct, alumina 15 pct, and sodium oxide about 5 pct. Potash, lime, and water are the next three most abundant constituents, running just a little over 2 pct each. Iron oxides are fairly constant at 2.75 pct. Titanium, manganese, magnesium, and phosphorus occur in amounts of less than 1 pct. All of the foregoing substances are combined as a glass exhibiting cellular structure. The weight of crushed but otherwise pit-run (undried) pumice runs around 1100 lb per cu yd according to figures furnished by various producers. The minimum and maximum weights per cubic yard reported are 1050 and 1400 lb, respectively. The 1400 lb per cu yd pumice contrasts with the pumice from most of the other

pits in that it is conspicuously wet when mined. No dry weight is available for this or other varieties produced.

Although lenses and interbeds of sedimentary clays and sands are present in many of the pumice accumulations, the chief impurity found in the pits is an extra-fine pink ash. This is not regarded as an impurity detrimental in nature to the product. Rather it is deliberately added to the crushed coarse pumice if the percentage of natural fines is too low. The ash therefore constitutes an impurity only when it occurs in amounts sufficient to hamper mining. Many pits show no such ash. In those that do, it occurs chiefly as overburden.

The production of pumice involves relatively simple pit and plant setups. The pumice area is traversed by both rail lines, the Southern Pacific in the Chemult area and the Great Northern at Bend, and good roads. The operations are usually either within a few miles truck haul to the railroad or immediately adjacent to it. Delivery from the standpoint of access to shipping terminals is therefore not a problem, and the situation is further eased by the fact that much of the production is shipped directly to the consumer by truck.

Mining is accomplished either by bulldozing to the plant bin, or by scoopmobiles, and in one place by a highline. As processing consists merely of crushing and screening, the plants consist of nothing more than rolls and screens. Practice varies among operations but in general the pumice is screened to about a half inch maximum. The selling of a natural or blended aggregate ranging in mesh from fines to coarse has been attended by difficulties introduced by segregation of fines during transportation. The consumer has thus been faced with the problem of drawing a somewhat classified charge of aggregate from his stockpiles rather than the desired blend. This situation has given rise to consumer complaint in the past. At least one producer who also operates a block plant is putting out a sized product which is blended to the desired proportions at the block plant. It is understood that some consumers size the mixed aggregate delivered to them to their own specifications. Drying the pumice before shipment has been considered.

No really permanent quarry and preparation installations exist at any of the pumice operations within the state. Perhaps the most striking feature about the industry is the concentration of producers in the area around Bend which is many miles to the north of the vast pumice field lying northeast of Crater Lake. The Bend area pumice deposits are scattered, limited in size, and covered with an overburden ranging from 1 to 20 ft or more. Nevertheless the proximity of the deposits to the cities of Bend and Redmond with their attendant services and supply of labor has proved to be an important factor. The Chemult area is more ideally situated than that at Bend from the standpoint of reserves, ease of mining, and proximity to two railroads. It is however in a very sparsely populated area 55 miles from Bend.

VOLCANIC CINDERS AND SCORIA

Infrequent use has been made of volcanic cinders and scoria. There are several large deposits of these materials in the state but most of them are poorly located with respect to consumption points and nearness to either rail or road transportation. Cinders and scoria when used as an aggregate in building blocks produce a heavier and stronger unit than those made of pumice.

Approximately the same specifications hold true for cinders and scoria as they do for pumice with respect to particle size. Color of the cinders ranges from red through brown to black.

HAYDITE

Haydite, an artificially expanded fossiliferous shale, is being produced in a small way at a plant about 40 miles northwest of Portland. Extensive beds of a fossiliferous, buff-colored shale occur in the area which is readily accessible to Portland and vicinity by highway and railroad. The expanded material is a brownish-red color and possesses a higher crushing strength than either pumice or scoria when used in precast concrete blocks. Haydite from this operation competes directly with pumice from central Oregon as an aggregate for lightweight building blocks in the Portland area. Higher processing costs of the haydite are offset to some extent by a smaller transportation charge (to Willamette Valley area) and by the saving of cement in the manufacture of the product since the haydite is less porous than pumice.

To be acceptable as a lightweight aggregate for concrete products, haydite must have a porous texture composed of myriads of tiny bubbles. Improper firing can produce coarse textured material having large voids, which both reduce the crushing strength and increase absorption of the cement mix.

Northwest Aggregates is currently enlarging its rotary kiln at the quarry at Sunset Tunnel on the Wolf Creek Highway, about 40 miles northwest of Portland. The plant will resume operation early in December and it is expected to produce 200 yd of finished material per day. The plant will be operated on a 24 hr day, 7 days a week, with approximately 15 men per day being employed. Pit-run material is crushed to minus 1½ in. before firing in the variable speed, 65-ft rotary oil-fired kiln. The expanded material is water cooled upon discharging and is then crushed and screened to the required sizes. The enlarged plant will be equipped with various controls to regulate feed, temperature, draft, and rotation of the kiln during the firing processes, the need for which was demonstrated in the first installation. Weight of the haydite crushed to minus ¼ in. averages about 1040 lb per cu yd, which produces a concrete block weighing approximately 40 pct less than sand and gravel units and about 1 or 2 lb lighter than pumice blocks. Crushing strength of the blocks can be varied by adjusting the amount of cement added to the mixture. Blocks with crushing strengths of from 2200 to 3000 psi are being produced. Northwest Aggregates will supply aggregate to Empire Building Materials Co., Portland, manufacturers of lightweight concrete blocks. Excess production will be available to the trade. Several monolithic concrete structures using haydite produced in the Northwest plant have been poured in the Portland area in the past few months. The material has been used as an aggregate for two poured roof slabs on large buildings with good success. Other uses for the material have included precast slabs for houses and burial vaults. Although haydite possesses a porous texture the porosity is formed by spherical, isolated bubbles rather than by tubes or voids. This condition reduces the absorption of cement greatly and also helps reduce the density of the concrete.

VOLCANIC TUFF

There are several excellent deposits of readily accessible volcanic tuff in the state but no use is being made of the material at the present time. In the past sawed blocks of tuff were used to build

durable structures in both eastern and western Oregon. Although tuff has been proven to be a durable, lightweight building stone it has not as yet been used as an aggregate for precast or monolithic concrete products.

Since volcanic tuff is composed mainly of pumice and volcanic ash, with minor amounts of clay and lumps of basaltic rocks, it offers no advantage over granular pumice, scoria, or cinders and possesses the further disadvantage of having to be crushed and sized before being used. Several short-lived attempts to produce accurately sized, sawed blocks of tuff have been made from time to time. When freshly quarried the stone can be sawed and shaped with ease, but it becomes quite hard upon exposure to the air. The main difficulties that confront a would-be producer of sawed tuff blocks are: (1) high quarrying and dressing costs plus a comparatively large capital investment for quarry preparation and stone sawing equipment, (2) relative inflexibility of operation from the standpoint of production of special sizes and shapes offered in precast units, (3) higher unit freight rates as compared to pumice, scoria, and cinders which take a lower rate because they are shipped in an unfinished state, (4) losses from damage suffered to finished blocks during handling, and (5) variation in the crushing strength of individual blocks due to differences in composition and texture. Care in selection of the rough stone would tend to eliminate this trouble but might result in the discarding of appreciable amounts of rough stone. On the other hand Oregon tuffs offer several positive advantages which place them in a better competitive position than the above disadvantages would at first seem to indicate. Tuff building stone possesses an inherent attractiveness of color, texture, and pattern that is largely lacking in precast units. A pleasing variety of contrasting stones can be readily secured by selecting material from different locations in the quarries. Cement apparently will be in short supply for some time to come, a factor favoring sawed blocks over precast units. Blocks of natural tuff should find a market in the construction of durable public buildings and private homes.

PERLITE

Perlite production in Oregon is presently confined to the operation of Dantore Products Division of Dant and Russell, Inc., on the Deschutes River in southern Wasco County. Details of this operation have been adequately described in a paper read at the El Paso regional meeting of the AIME in October 1948 by Mr. Fred Gustafson,[2] resident mining engineer of the Dantore Division. An earlier report on the property was made by J. E. Allen.[3] Recently the company announced that it will move its processing plant from St. Helens to the mine and that an insulating, noncombustible accoustical tile plant would also be erected adjacent to the beneficiation and expansion plants. Total cost of this construction has been stated to be one million dollars with completion date set for the summer of 1949.

DIATOMITE

Diatomite has been used for many years in the production of lightweight concretes and also for conditioning concrete mixtures for good insulation properties. No block manufacturers are now using diatomite in the state.

Tonnage figures of diatomite used as a lightweight aggregate in Oregon are not available. Practically all production is from one quarry in Deschutes County. The material is produced at the quarry and is sold for a variety of uses. Approximately one-eighth of all diatomite produced in the United States is used as a lightweight aggregate.

Summary and Conclusions

The lightweight aggregate industry in the state is dominated by the various pumice producers in the Bend-Chemult area of central Oregon. These producers are essentially running a materials-handling business rather than a true mining and milling enterprise. Equipment is usually simple and the crushing and screening is accomplished with a minimum of capital outlay.

Operators in the area near Bend are faced with the necessity of finding new pits from time to time since individual deposits have tended to be small or covered with overburden which varies greatly in thickness. In the Chemult area operators have an unlimited supply of material to choose from which has little or no overburden but which at the same time is unprotected from surface moisture and, during the winter months, from freezing conditions, both of which tend to place the operators in a less advantageous position than those in the Bend area.

The production of haydite is just being started but as it finds wide acceptance there would appear to be no obstacle to its continued production since unlimited deposits of suitable material are readily accessible.

The production of tuff in the form of sawed blocks could offer direct competition to other lightweight aggregates provided several production difficulties could be ironed out. It is doubtful however if tuff blocks will ever find the same widespread acceptance that other lightweight aggregates are currently enjoying.

The use of expanded perlite and obsidian appears to have great promise. Whether perlite will be used widely as an aggregate in precast concrete blocks remains to be seen but its continued and expanding use as a lightweight plaster sand and in lightweight insulating wallboards seems practically assured.

The use of diatomite in lightweight concrete is not new but will probably always be limited to a few specific applications.

For the first time in the history of the Pacific Northwest the construction of wood frame buildings is slowly yielding to the inroads of lightweight concrete structures utilizing either precast units or monolithic construction. This change has been very gradual in the past but now appears to be accelerating. The change has been brought about by a number of factors, chief among them being the current scarcity of wood for construction coupled with high heating costs for frame buildings and the desire on the part of many builders to erect more durable structures.

At present the market for all of the lightweight materials appears to be unlimited but this condition will undoubtedly change in time. Eventually the picture will be one of a few well-established, carefully run operations for each of the various products which have tailored their production to a market that has been fairly well defined but which will be increasing steadily for a number of years.

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Economics of Coal for West Coast Power Generation

By CLAUDE P. HEINER,* Member AIME

While the title of this paper embraces the entire West Coast, the author, in the interest of simplification, has confined the discussion to California—particularly the central section.

California's population has risen 45 pct since 1940. Its electric requirements have also increased, not only because of the growth in industry and population but also because of the widespread tendency of all types of electric consumers to use more electricity than ever before. The growth of California's electric utilities is shown by published data covering operations of three of its large systems and is given in Table 1.

New Capacity Steam Driven

In meeting these additional electric loads there has been a substantial increase in generation from fuel burning plants as shown by the published energy statistics given in Table 2.

Increased Fuel Oil Consumption

A study of construction plans of the three electric utility systems named in Table 2 clearly shows that expected new electric loads are to be met, to a large extent, by new steam generating capacity as shown by Table 3. D. D. Smalley, Vice President of the Pacific Gas and Electric Co., in an address before the Pacific Coast Electrical Association in June 1948, stated that California utilities plan to meet new electric loads through greater use of steam plants and that in 1951 approximately 45 pct of the area's electric production would be by steam as compared to 33.6 pct in 1946. He stated that if load growth develops as expected and if the year 1952 is dry, thereby requiring high load factor steam operation, the Pacific Gas and Electric Co. would need the equivalent of nearly 25 million barrels of fuel oil.

Federal Power Commission reports show that the energy input to the Pacific Gas and Electric Co. system was approximately one billion kilowatt-hours greater in 1947 than in 1946. They also show that the steam plant operating capacity factor in 1946 was approximately 35 pct; in 1947 it was 72 pct due, probably, to the extreme drought.

Table 3 shows that Pacific Gas and Electric Co. now has under construction 327,000 kw of hydro capacity which, by 1950, will bring its total hydro generating capacity to 1,313,899 kw. In addition to hydro capacity under construction that company also has 975,000 kw of steam generating capacity under construction, which by 1951 will bring its total steam capacity to 1,560,834 kw. If it is assumed that this total steam electric capacity is operated at a capacity factor of 45 pct in 1951, over 6 billion kilowatt-hours would be generated. If the load growth on the Pacific Gas and Electric system continues at the current rate of approximately one billion kilowatt-hours per year and if it is assumed that 70 pct of this increase would be generated by steam (30 pct assumed to be generated by hydro facilities with average water conditions), the steam electric production in 1960 would amount to 12 billion kilowatt-hours, which would require fuel the equivalent of 24 million barrels of oil or 6 million tons of coal.

Government Projects Inadequate

Much has been written with respect to the plans of the Department of Interior in regard to the installation of hydroelectric plants as a part of multipurpose dams relating to reclamation, flood control, and power generation. An examination of the effect of such plans on the power supply for central and northern California is of interest. The Department of Interior now has five 75,000 kw units at its Shasta hydro plant on the Sacramento River. It now appears that its three 25,000 kw unit Keswick hydro plant on the same river will be available during the winter of 1949 to 1950. Its estimates show that in a dry year there is sufficient water for operation of Shasta units at an average load factor of 36 pct and Keswick units at a load factor of 41 pct. It is also giving consideration to the development of the Pine Flat and Haas hydroelectric plants on Kings River for generating capacities of 45,000 kw each. The total installation of Government units in Central Valley and Kings River in California is relatively small when compared with the

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fast-growing electrical requirements of the area.

Obviously the Department of Interior recognizes the effect of drought on the output of these plants inasmuch as its plans include installation of a 240,000 kw steam plant at Delta east of Berkeley and a 90,000 kw steam plant at Fresno.

More Colorado Power Remote

To supplement California's electric power supply, the Department of Interior plans ultimate development of projects of considerable magnitude on the Green and Colorado rivers but these plants would be extremely expensive and, inasmuch as they are very remote from the West Coast, the cost of transmission facilities would be great. Furthermore final division of Colorado river waters among the respective upper and lower basin states would be necessary, and because construction progress would depend on year to year appropriations by Congress, if the projects are approved, a number of years will be required, in the author's opinion, before electric energy will flow from these sources to California.

California Faces Oil-gas Importation

For the past 25 years California has not only supplied all of its fuel oil requirements but those of other West Coast States and Arizona, Nevada, and to some extent Idaho, as well as a large portion of the requirements of China and Japan. California is now confronted with the importation of oil.

It has for many years supplied its populace with large quantities of natural gas. However, during the past year the El Paso Natural Gas Co. constructed a line from the west Texas field to Blythe, Calif., for the ultimate delivery of 305 million cubic feet per day to supplement southern California supply. To supplement the locally available dry natural gas supply from northern California fields the major natural gas company serving that area has under consideration the purchase of 100 million cubic feet of natural gas per day from southern California gas companies to be delivered through the El Paso line for the period ending 1953. In addition to this temporary arrangement the northern California gas

Table 1 . . . Growth of Electric Utilities in California

Name of Utility	Electric Energy Sales,[a] Billion Kilowatt-hours		
	1940	1947	Increase, Pct
Pacific Gas and Electric Co.	4.7	8.5	81 (7 yr)
Southern California Edison Co.	2.9	5.6	93 (7 yr)
	Fiscal Year Ending June 30		
	1940	1946	Increase, Pct
City of Los Angeles	1.49	2.56	72 (6 yr)

[a] Delivered to customers' meters.

Table 2 . . . Increase in Generation of Electric Energy

Name of Utility	Electric Energy Generated Billion Kilowatt-hours		
	1940	1947	Increase, Pct
Pacific Gas and Electric Co.			
From hydro plants	4.24	4.90	16
From steam plants	0.45	3.71	822
Purchases from and net interchanges with other utilities	1.37	1.81	32
Southern California Edison Co.			
From owned and leased hydro plants	3.45	4.03	17
From owned steam plants	0.14	2.40	1,715
Purchases from and net interchanges with other utilities	0.05	0.23	460
	Fiscal Year Ending June 30		
	1940	1946	Increase, Pct
City of Los Angeles			
Los Angeles units at Hoover Dam	1.73	2.85	65
From owned hydro plants	0.25	0.42	68
From owned and leased steam plants	0.06	0.20	333

Table 3 . . . Comparison of Present Electric Generating Capacity with that now under Construction

System	Electric Generating Capacity, Kilowatts			
	In Service at End of 1947		Installed in 1948 or Under Construction at End of 1948	
	Hydro	Steam	Hydro	Steam
Pacific Gas and Electric Co.	986,899	585,834	327,000	975,000
Southern California Edison Co.	904,520[a]	396,000	35,000	255,000
City of Los Angeles	621,025[b]	403,800[c]		225,000[d]

[a] Including 495,000 kw leased at Hoover Dam.
[b] Including 495,000 kw leased at Hoover Dam.
[c] Including 86,300 kw leased on "when as and if" basis from Southern California Edison Co.
[d] Reference 45th Annual Report of Board of Water and Power Commission, City of Los Angeles, for fiscal year ending June 30, 1946.

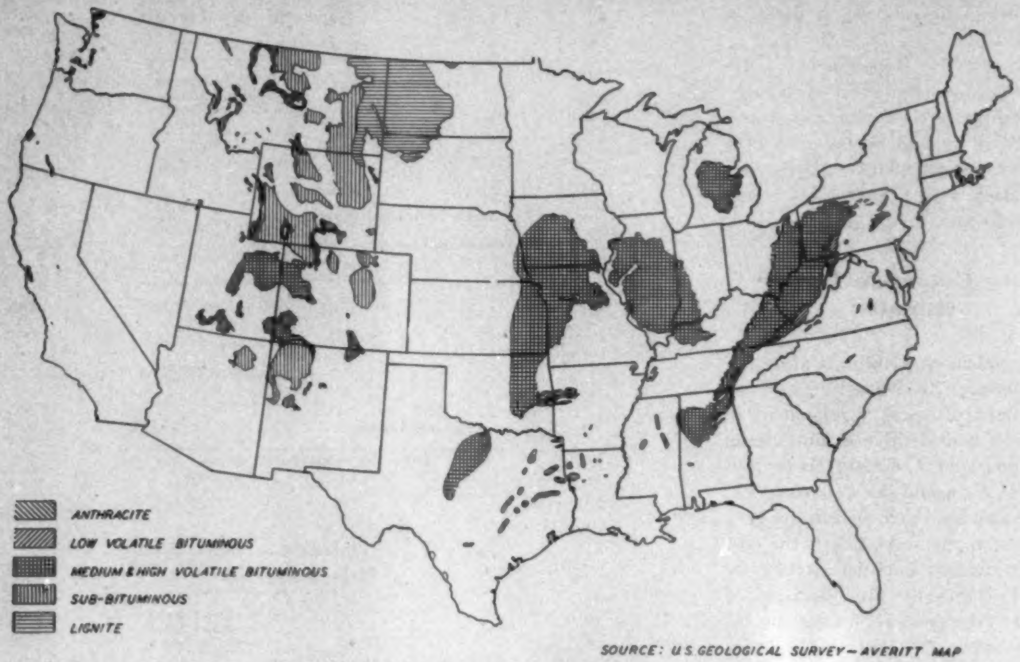

FIG 1—Coal fields of the United States.

service company has entered into a preliminary agreement with the El Paso Natural Gas Co. for the purchase of 100 million cubic feet of natural gas per day for a term of 25 years, to be delivered at the California border near Needles and, at its option, to increase purchases up to 300 million cubic feet per day by 1954. It is understood that the El Paso company plans the construction of a new line from San Juan, N. M., to Needles, Calif.

It is generally believed that during the greater part of the year natural gas transported into California will be used to meet the domestic and commercial requirements of the state's fast-growing population and that little gas will be available for large industries. Because of the desire of natural gas distributors to reserve such fuel for domestic and commercial use it is believed that use of natural gas for electric power generation, even on a dump basis, will likely decline.

Fuel Oil Immediate Basic Fuel

For the immediate future fuel oil likely will be used as a principal fuel for California steam electric generating plants and, because of the general increase in consumption of fuel oil in the United States, this oil may be supplied indirectly from foreign sources such as South America and the Middle East. Consideration has been given to the exportation of west Texas crude to California via pipeline which would require that eastern seaboard markets, now supplied from Texas, be supplied from some other source, probably South America, at such time as Arabian crude can meet the European crude market currently being supplied by South America. On the other hand much has been written during the past 30 years concerning the rapidly declining fuel oil reserves of the United States. The available known reserves of crude oil at existing rates of consumption have for many years been variously estimated at from 15 to 30 years but it is understood that at this time proven oil reserves of the United States, at present rate of consumption, are greater than at any time during the past 25 years. However, it is likely that during the years to come domestic crude oil will come from deeper horizons which will necessitate increased development costs and higher recovery costs.

Activities of the major oil companies and the Federal Government indicate cognizance of the fact that it will be necessary to find new sources for oil and gasoline within some foreseeable future time, as indicated by the following plans:

1. Supplementing reserves with imports from recently discovered oil fields of South America and the Middle East.
2. Use of synthetic conversion of gaseous fuel to liquid fuel.
3. Research and construction of pilot plants to convert coal to gas and to synthesize this gas resulting in the manufacture of gasoline and fuel oil.
4. Extraction of oil from western shales.
5. Exploration for possible increased oil production from the continental shelves.

Fuel Oil Prices May Increase

Imports of fuel oil from foreign sources will likely increase the price of fuel oil. Greater consumption of gasoline and diesel fuel and improvements in refining processes, resulting in much higher recovery of these commodities, will also tend to increase the price of fuel oil.

While it is believed that the plan of supplementing domestic fuel oil reserves with imports from South America and the Middle East may be economically feasible in a peacetime economy, it is very doubtful if it would be practical in case of national emergency. When consideration is given to the great demand for petroleum pro-

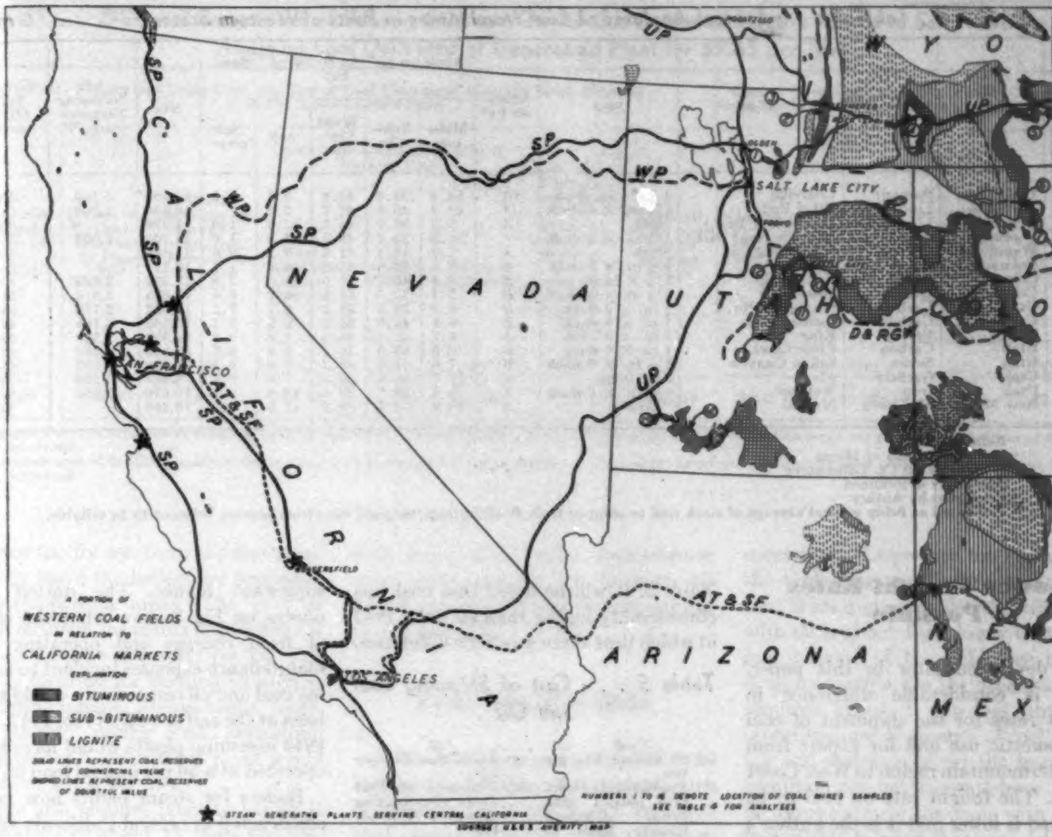

FIG 2—A portion of western coal fields in relation to the California market.

ducts during the past war and the burden of such demands on the United States together with the present day accelerated use of oil for general purposes, it is believed that the availability of oil for the generation of electric power in California would be somewhat precarious in event of war.

In discussing the use of oil and natural gas for generation of electric power in California it is interesting to note the opinions of electric utility managements operating in north central Texas in connection with the design of steam electric generating plants. The vast reserves of crude oil and natural gas in Texas are well known and for years natural gas has been the principal fuel for the generation of electric power in that state with oil as an adjunct for use during extremely cold weather or emergencies. Plants of major utilities in north central Texas are now being designed for ultimate conversion to coal, because it is the opinion of managements of those utilities that within the useful life of the plants, natural gas for the generation of electric power will become unavailable due to exhaustion or be made unavailable for industrial purposes by state legislative action. In the event of such legislative action it is believed that the state would likely curtail out-of-state shipment of gas prior to imposing restrictions as to use within its own boundaries.

It is understood that California utilities are now constructing steam plants for possible ultimate conversion to solid fuel.

Ample Coal Reserves Available

Fortunately, with the decline in oil reserves within the foreseeable future, the United States has vast solid fuel reserves. The accompanying map, Fig 1, shows the location and the general quality of available coal reserves within the United States. It will be noted that a large portion of these reserves is in the western states and Fig 2 is an enlargement of this latter area to show the relationship of coal reserves of southwestern Wyoming, western Colorado, Utah, and northwestern New Mexico to possible California markets. This map shows the location of coal of known and doubtful commercial value. It also shows the quality of the coal. Coals from this region are of excellent quality as is indicated by analyses of typical samples from the more important fields given in Table 4. Moisture, ash, and sulphur contents of the bituminous coals are low and the heat value on an "as received" basis ranges from 11,000 to almost 13,000 Btu. Ash fusion temperatures are higher than those of some midwestern coals.

Because of the distance from the intermountain states to central California and increases in the price of coal since the war it is probably the general opinion that, if coal were used instead of oil for the generation of electric energy, there would be a considerable increase in production cost. Actually the difference would not be great. While there has been a gradual increase in the mine price of coal since the war, there has been a much greater increase in the price of fuel oil.

Table 4 . . . Typical Analyses of Coal from Mines in Parts of Western States

Map Reference Number[a]	State	County	Mine	Size	Analysis by[b]	Analyses on "As Received" Basis, Pct: Moisture	Volatile	Fixed Carbon	Ash	Sulphur[c]	Btu	Ash Softening Temperature, °F	Grindability (Hardgrove)
1	Utah	Summit	Coalville	1 × ¼ in. slack	*A*	14.4	36.0	43.9	5.7	1.3	10,690	2,140	38[d]
2	Wyoming	Lincoln	Elkol Bed	1⅝ in. × 0 slack	*A*	19.9	35.1	42.2	2.8		10,430	2,260	
3	Wyoming	Lincoln	(Kemmerer Dist.)	Slack	*A*	5.5	35.7	46.5	12.3	1.0	11,980		45[d]
4	Wyoming	Sweetwater	(Rock Springs Dist.)	1⅝ in. × 0 slack	[e]	11.5	35.7	48.4	4.4	1.0	11,700	2,090	35[d]
5	Wyoming'	Carbon	Elk Mountain	Slack	*A*	7.8	41.5	41.5	9.2	0.6	11,380		40[d]
6	Colorado	Routt	Moffat	1½ in. × 0 slack	*A*	8.5	38.5	48.5	4.5	1.1	12,230		35[d]
7	Colorado	Routt	Edna Strip	1¼ × ¼ in. pea	*B*	8.1	40.7	47.6	3.6	2.0	12,232	2,025	35[d]
8	Colorado	Gunnison	Somerset	1½ in. × 0 slack	*B*	5.4	37.5	51.1	6.0	0.6	12,885	2,510	51.8
9	Utah	Carbon	Sunnyside No. 1	1 in. × 0 slack	*B*	6.3	36.8	50.2	6.7	1.2	12,932	2,750	53.9
10	Utah	Carbon	Castle Gate	1 in. × 0 slack	*B*	6.3	40.9	46.3	6.5	0.5	12,586	2,169	47.0
11	Utah	Emery	King	1 in. × 0 slack	*A*	6.2	42.4	44.4	7.0	0.6	12,590	2,310	48[d]
12	Utah	Carbon	Clear Creek	1 in. × 0 slack	*B*	8.0	39.9	46.7	5.4	0.5	12,340	2,520	42.8
13	Utah	Sevier	Salina Canyon	1½ in. × 0 slack	*B*	7.6	41.2	43.3	7.9	0.4	11,530	2,095	42[d]
14	Utah	Garfield	Alvey	2 in. lump	*A*	17.7	36.2	38.3	7.8	0.4	9,840	2,280	38[d]
15	Utah	Iron	Webster	1⅝ in. × 0 slack	*A*	6.1	39.7	39.6	14.6	6.1	10,670	2,150	42[d]
16	New Mexico	McKinley	Mutual	"Tipple"	*A*	13.8	34.1	40.2	11.9	0.5	10,360		35[d]

[a] Refer to Fig 2.
[b] *A*—U.S. Bureau of Mines
B—Utah Fuel Co. Laboratory
[c] Separately determined.
[d] Estimated by Author.
[e] Estimated as being general average of slack coal as shipped from Rock Springs; original data from sources believed to be reliable.

Lower Freight Rates Possible

As developed later in this paper, there is considerable difference in freight rates for the shipment of coal for domestic use and for export from the intermountain region to West Coast points. The freight rate on coal to be exported is lower and it is the author's opinion that the export rate could be obtained to deliver coal into central California for the generation of electric power. The curves in Fig 3 show the trend since 1940 in prices of coal and oil delivered to the San Francisco Bay area. Prices are in cents per million heat units (Btu) in the fuels based on published prices at the end of each year assuming the figures given in Table 5. It will be noted that coal was considerably higher than oil until 1947 at which time there was little difference.

Table 5 . . . Cost of Shipping Coal and Oil

Coal	Oil
(*a*) 25 million Btu per ton	(*a*) 6.3 million Btu per bbl
(*b*) Published freight rate plus 1 cent from Carbon County, Utah, to San Francisco on coal for export	(*b*) Delivered at Port Costa plus barging charge of \$0.08 per bbl

Coal Entails More Equipment

Where coal is used to generate electric power more expensive equipment is necessary than with oil; also operating and maintenance expenses are somewhat higher. The dotted line curves on Fig 3 show what the effect of fixed charges and operating and maintenance expenses incident to burning coal and oil respectively would have been at the end of years 1946, 1947, and 1948 assuming plants would have been operated at a 50 pct annual load factor.

Boilers for steam plants now being constructed in central California are of a size that would require that coal be burned in pulverized form. Coal requires track hoppers and car dumpers for unloading; facilities to handle it in and out of storage and from railroad track hoppers to plant bunkers; bunkers for its storage above pulverizing mills; pulverizing mills, and fans to transport it to the boilers; and ash handling equipment. Precipitators to

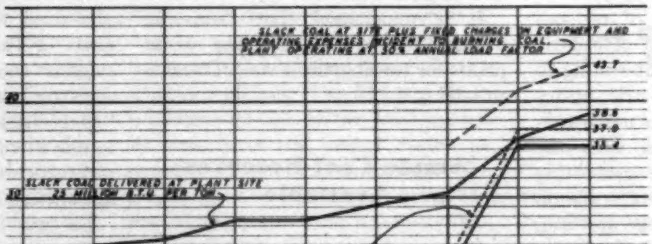

FIG 3—Trends in prices of fuel oil and coal in the San Francisco area.

Table 6 . . . Economic Comparison of Burning Coal and Oil for Generation of Electric Power in San Francisco Area Assuming Coal Delivered at Generating Plant for $9.65 per Ton

Cost of Operation Using Coal, per Ton of Coal Consumed with 300 M-kw Plant at 50 Pct Annual Load Factor								Cost of Operation Using Oil, per Bbl Consumed with 300 M-kw Plant at 50 Pct Annual Load Factor			
			Operating Expenses Incident to Burning Coal								
Heat Value of Coal Btu per Lb "as Received"	Cost of Coal Delivered to Plant Site	Fixed Charges on Plant Investment Incident to Burning Coal	Coal Handling and Ash Disposal	Operating Labor	Maintenance	Total Fixed Charges and Operating Expenses Incident to Burning Coal, Other than Cost of Coal at Site	Total All Costs Incident to Burning Coal	Fixed Charges on Plant Investment Incident to Burning Oil	Operating and Maintenance Expenses Incident to Burning Oil	Cost of Oil Delivered to Plant Site which with Fixed Charges, Operating and Maintenance Expenses is Equivalent to Price of Coal in Column (2)	Total All Costs Incident to Burning Oil
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
12,500	$9.65	$0.95[a]	$0.20	$0.054	$0.06	$1.264	$10.914	$0.074[b]	$0.029	$2.622	$2.725

[a] Assumes cost of facilities incident to burning coal at $17 per kw; boiler efficiency (operating) at 87 pct; station auxiliary power consumption at 8 pct of gross generated.

[b] Assumes cost of facilities incident to burning oil at $4.50 per kw; boiler efficiency (operating) at 86 pct; station auxiliary power consumption at 7 pct of gross generated.

remove the fly ash from the flue gases as they leave the boilers are necessary in metropolitan areas. The cost of these facilities for plants of 300,000 kw size amounts to about $17 per kw. The cost of facilities for burning oil such as unloading pumps, storage tanks, transfer pumps, piping and preheating facilities for a 300,000 kw plant would be about $4.50 per kw.

Coal also requires labor to handle it amounting to about 15 cents per ton; labor to handle and dispose of ashes amounting to about 5 cents per ton; labor to operate fuel grinding equipment amounting to about 5 cents per ton of coal. Coal results in slightly higher boiler maintenance than oil because of ash. It is estimated that the maintenance of fuel grinding and fuel and ash handling equipment together with incremental boiler maintenance over that required for burning oil would amount to about 6 cents per ton of coal burned.

Coal Use Feasible

Table 6 shows a comparison of costs incident to burning coal and oil in a 300,000 kw plant and it will be noted that segregation is made between fixed charges, coal and ash handling expense, operating labor and maintenance expenses. The load factor at which a plant is operated naturally has a bearing on the amount of fuel consumed and the table assumes an annual load factor of 50 pct with either fuel; coal quality also has a bearing on quantity consumed and thus influences fixed charges per ton consumed; the table assumes 25 million Btu per ton. With a given boiler the efficiency with oil is about 1 pct lower than with coal because of the difference in hydrogen contents. On the other hand oil requires about 1 pct less auxiliary power because of absence of coal grinding and conveyance, so the heat consumption per net kilowatt-hour would be approximately the same with either fuel. Table 6 shows that coal delivered to a central California electric generating plant at $9.65 per ton would be equivalent in price to oil delivered at the same site at $2.62 per barrel considering fixed charges and operating and maintenance expenses incident to use of the two fuels and assuming operation at 50 pct annual load factor.

The quality of coal has an effect on

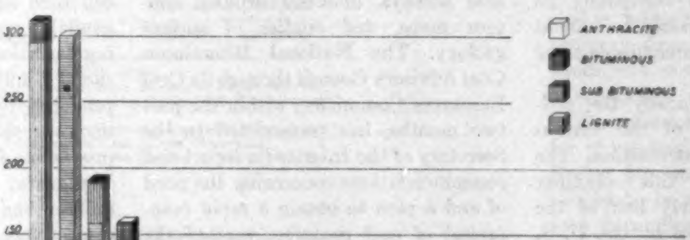

FIG 4—Original coal resources in the United States.

Table 7 . . . Economic Comparison of Burning Coal and Oil for Generation of Electric Power in San Francisco Area Assuming Oil at Present Price

Cost of Operation Using Coal, per Ton of Coal Consumed with a 300 M-kw Steam Plant at 50 Pct Annual Load Factor								Cost of Operation Using Oil, per Bbl of Oil Consumed with a 300 M-kw Steam Plant at 50 Pct Annual Load Factor			
Heat Value of Coal Btu per Lb "As Received"	Cost of Coal Delivered to Plant Site to be Equivalent to Oil at Present Price Stated in Column (11)	Fixed Charges on Plant Investment Incident to Burning Coal	Operating Expenses Incident to Burning Coal: Coal Handling and Ash Disposal	Operating Expenses Incident to Burning Coal: Operating Labor	Operating Expenses Incident to Burning Coal: Maintenance	Total Fixed Charges and Operating Expenses Incident to Burning Coal, Other than Cost of Coal at Site	Total All Costs Incident to Burning Coal	Fixed Charges on Plant Investment Incident to Burning Oil	Operating and Maintenance Expenses Incident to Burning Oil	Present Cost of Oil Delivered to Plant Site*	Total All Costs Incident to Burning Oil
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
11,000	$6.794	$0.840	$0.20	$0.046	$0.06	$1.146	$7.94	$0.074	$0.029	$2.23	$2.333
11,500	7.236	0.895	0.20	0.049	0.06	1.204	8.44	0.074	0.029	2.23	2.333
12,000	7.549	0.920	0.20	0.051	0.06	1.231	8.78	0.074	0.029	2.23	2.333
12,500	7.996	0.950	0.20	0.054	0.06	1.264	9.26	0.074	0.029	2.23	2.333
13,000	8.453	0.950	0.20	0.057	0.06	1.267	9.72	0.074	0.029	2.23	2.333

* Assuming $0.08 barging charge.

the amount of fuel required to generate a given amount of electric energy not only because of the difference in heat content per ton but also because coals of the lower heat value usually cannot be burned at the same boiler efficiency due to losses caused by greater amounts of moisture and ash. The present price of oil, including fixed charges on incidental facilities required in a 300,000 kw plant operating at a 50 pct load factor, and operating expenses incident to its use, is about $2.33 per barrel. Table 7 shows the price that coal, containing various heat contents per ton, would have to be delivered to a San Francisco Bay area electric plant to make it comparable to oil delivered to the same plant at $2.23 per barrel. It shows that 22 million Btu per ton coal would have to sell for $6.79 per ton to be comparable to oil at $2.23 per barrel, whereas coal containing 26 million Btu per ton could be sold at $8.45 per ton and be comparable to oil at $2.23 per barrel.

Fig 4 shows graphically the estimated coal reserves of the various states by quality classification. The quantities shown in this columnar chart are approximately half of the amounts usually shown by the U. S. Geological Survey but are understood to represent the current opinion of Dr. Fieldner of the U. S. Bureau of Mines after allowance of a larger safety margin in the estimates themselves and in the mining losses.

There has been considerable controversy over the actual extent of our coal reserves which have been estimated from various geological observations, measurements of bed thicknesses, extent of surface outcroppings, trenching and exploratory tunnels, shafts and some drill cores made many years ago. There is even greater controversy over the amount of coal that can actually be recovered. Fig 4 shows 44 billion tons of bituminous coal in the state of Utah but it is doubtful, in the author's opinion, that more than 2 billion tons of coal comparable to that now being produced in the Carbon-Emery County fields, may be recovered by present methods.

Reappraisal Coal Reserves Necessary

There is great need for more accurate information concerning both the quantity and quality of solid fuel in this country—West as well as East—and much can be learned from accurate area surveys, diamond drilling, contour maps, and studies of surface geology. The National Bituminous Coal Advisory Council through its Coal Resources Committee, within the past two months, has transmitted to the Secretary of the Interior its report and recommendations concerning the need of and a plan to obtain a rapid reappraisal of coal resources east of the Mississippi River. A thorough and painstaking geologic and engineering survey of coal resources west of the Mississippi River should likewise be undertaken as rapidly as possible. The mountainous western terrain and the variability of western coal beds in extent, pitch, thickness, and quality will, no doubt, necessitate more painstaking study—requiring longer time and entailing relatively more expense—than the study of eastern fields.

Even though there appears to be much less commercially minable coal than we have been generally led to believe, there is undoubtedly sufficient coal in the Utah, Colorado, Wyoming, and New Mexico fields to supply all conceivable requirements for a period well beyond the interest of several future generations.

Table 8 shows the annual production from all Utah mines and those in the Rock Springs and Kemmerer, Wyo., areas for the 10 year period ending 1947. The 1947 production from Utah mines exceeded production during the war years whereas there has been a decline in production from the Rock Springs mines since the war due principally to greater use of diesel electric power by the Union Pacific Railroad.

An analysis of the potential coal production from Utah mines on a two shift full time basis, with consideration to available trained manpower and housing facilities, indicates that an additional 4 million tons per year could be produced to supply new West Coast markets. Similar available potential production from the Rock Springs and Kemmerer, Wyo., fields amounts to 2 million and 500,000 tons per year, respectively, making a total additional production capacity of 6½ million tons. Such productive capacity assumes absence of strikes, adequate railroad car supply, and a six-day week but makes allowance for ordinary mine disability and usual holidays. It should be pointed out here that such additional production could best be obtained by storing coal near the point of consumption during off-peak periods of domestic consumption—generally between early March and September. To emphasize

this point, Utah commercial coal mines showed the average monthly distribution (given in Table 9) of annual production for the 10 year prewar period ending 1939, when producton was not influenced by war or important contractual obligations for coal.

From data previously presented it is obvious that steam plants installed and under construction in central California will probably consume the equivalent of 3 million tons of coal per year by 1951 and that if the present program of meeting a large portion of required additional electric generating capacity by steam driven equipment continues, 6 million tons could be consumed in 1960. In dry years, with reduced generation from hydro facilities, fuel consumption would be considerably greater. Thus, the coal productive capacity necessary to supply all fuel requirements of steam electric plants now installed or that probably will be installed in central California by 1960 is already in existence in Utah and western Wyoming alone. Frankly this capacity is looking for a market and when found it can very easily be supplied with coal.

Reserves Should Be Assigned to Use

In order to outline some of the problems of the coal industry in supplying this potential demand, let us assume that an average of 3½ million tons of coal would be required per year for the generation of electric power in central California. Obviously the consumer of that quantity of fuel would desire to have blocked out and held in reserve coal for 25 years supply, or about 90 million tons; in other words that quantity must be assigned for specific consumption and it must not only be proved but must be amenable to economical mining.

Inasmuch as ownership or control of coal reserves is related to surface area of land, a discussion of this relationship seems in order. Nature has not deposited coal beds in a manner that will permit their complete extraction by presently known mining methods. In compiling inventories of coal reserves it has been the practice for some years to include all coal in beds above a minimum thickness of 14 in. at a depth not to exceed 3000 ft. Thus, in areas underlaid with multiple coal beds, generally the case in western coal fields, the reserves usually stated for that area include all coal in each bed above the arbitrary datum. In practice it has too often been found that removal of coal from a single bed will make extraction from others extremely hazardous, if not impossible. This is frequently true under careful mine development plans even when the uppermost minable bed is extracted first. Some of the factors affecting minability of multiple seams are distance between the beds, character of the intervening rock, and the amount and character of overburden.

Recovery Limited in Mountainous Region

In a given area of minable coal only a portion of the total may practically be extracted and in the western states an extraction of 60 pct of the total coal in any one bed is considered good practice by present methods. A figure often used assumes a yield of 1000 tons per acre foot and anticipates about 57 pct recovery of total coal, the balance being left as unrecoverable for various reasons. Conditions in many western mines require that some top coal be left to protect the roof. When bottom coal is deliberately left it is either to assure a firm floor for maneuvering equipment or to prevent the inclusion of impurities.

The minimum bed thickness required for economical mining of coal in the Rocky Mountain States is now considered to be about 4 ft but this will vary depending upon the character of the roof, value of the coal, and other conditions.

Mining experience in Carbon County, Utah, the Paonia region of western Colorado, and the Rock Springs area in Wyoming indicates that maximum recovery of perhaps 8000 tons per surface acre or 5 million tons per section (640 acres) may be assumed. Even where there is more than one minable bed the extraction per acre may not exceed this figure.

Table 8 . . . Annual Coal Production from All Utah Mines and Mines in Rock Springs and Kemmerer, Wyo., Areas 10 Year Period Ending 1947

Year	From All Utah Mines[a]	From Rock Springs, Wyo., Area	From Kemmerer, Wyo., Area
1938	2,946,951[b]	3,315,811[e]	426,490[e]
1939	3,284,904[b]	3,527,411[d]	449,002[d]
1940	3,575,586[b]	3,849,691[e]	452,228[e]
1941	4,076,779[b]	4,520,116[e]	486,297[e]
1942	5,516,849[c]	5,561,360[e]	580,980[e]
1943	6,781,298[c]	5,992,451[e]	616,622[e]
1944	7,206,107[c]	6,136,979[e]	543,966[e]
1945	6,738,462[c]	6,251,290[e]	500,884[e]
1946	6,166,410[c]	4,438,618[e]	395,537[e]
1947	7,619,378[c]	4,907,680[d]	420,636[d]
Totals	53,912,724	48,601,407	4,872,650

[a] Includes captive mines.
[b] Figures taken from Bureau of Mines records.
[c] Figures taken from Industrial Commission of Utah records.
[d] Figures taken from the Annual Report of the State Inspector of Coal Mines, Wyoming.
[e] Figures taken from Bureau of Mines records.

Table 9 . . . Average Monthly Distribution of Production from Utah Coal Mines

Month	Percentage of Annual Production
January	13.0
February	10.4
March	7.5
April	5.0
May	4.0
June	3.7
July	3.7
August	5.9
September	9.6
October	12.0
November	11.9
December	13.3
Total	100.0

Leasing Act Limits Controllable Reserves

Perhaps 70 pct of the coal reserves in the western states lie under Government land and the Mineral Leasing Act, as amended by the 80th Congress, permits no person, association, or corporation other than railroads operating as common carriers to take or hold coal leases from the Government, at any one time, exceeding 2560 acres (4 sections) in any one tract, or in the aggregate acreage 5120 acres (8 sections) in any one state. Under this act a single company cannot practically hold leases in Government land in any one state containing more than 40 million tons of recoverable coal. Therefore, under present law and presently known mining methods it would be possible for a single company to control 90 million tons (3½ million tons per year for 25 years) only by leasing Government land, known to be underlaid with coal, in three states.

At present day prices the cost of developing a mine in mountainous western areas may be assumed to be about $7.75 per ton of annual mine capacity, made up as shown in Table 10.

Table 10 . . . Cost of Developing a Mine in Western Area

Capital Expenditure	Estimated Cost per Ton of Annual Mine Capacity
Mine	$4.00
Tipple including preparation and washing equipment	1.00
Housing and community facilities	2.75
Total	$7.75

Thus, the assumed coal requirements of 3½ million tons for central California would represent an investment of about $27,000,000. Such an investment would require a firm commitment on the part of the buyer to enable the mining company to finance the improvements.

There has been a rapid increase in demand for slack coal (1⅝ in. by 0 and 1 in. by 0) and it often has to be prepared by crushing from mine-run sizes—it is no longer a byproduct. Consequently any slack coal produced for generation of electric power in California would have to carry the full overall cost of production as it could not be assumed to be subsidized by the larger sizes of lump coal.

Lower Mining Costs Doubtful

With such a high capital cost to provide productive capacity and, lacking any particular benefit of subsidy from the larger sizes of coal, it may well be asked what may be expected in the way of possible cost and price reductions with the use of newly developed mining machines so widely publicized during the past few months. More experience with this new machinery will be required before definite predictions can be made but the following appears certain:

1. The capital cost of new machinery will be relatively high.
2. Application to western mines will be limited.
3. Trend of mine labor costs will likely be upward.
4. Power consumption, and hence power costs, will likely increase.

These factors will possibly offset a large part, if not all, of savings that might be expected through use of this new and revolutionary mining machinery; any promise of a decrease in coal prices due to its employment seems dim at this time, but the possibility does exist. Such machinery will, no doubt, alleviate shortages of mine labor as well as the housing and community problems of coal mining towns and, in general, ease mine production problems. At the end of 1948 Utah slack coal sold at $4.60 per ton f.o.b. cars at the mine and it is the author's opinion that, since any coal for West Coast electric power generation must carry the full mine production expense, no price reduction can definitely be predicted to result from use of new mining machines.

Railroad Facilities Adequate

The coal regions of Utah, southwestern Wyoming, western Colorado, and northwestern New Mexico are within close proximity to main transcontinental railroads and, in most cases, are already connected to main lines. These gathering lines and their relationship to main lines, together with presently available trunk lines connecting the intermountain region with the West Coast, are shown by Fig 2. It will be noted that the Santa Fe runs between northwestern New Mexico and southern California points; the Union Pacific between Rock Springs and Los Angeles; the Southern Pacific from Ogden to California; Denver and Rio Grande Western from western Colorado and Utah to Salt Lake and Ogden; and the Western Pacific from Salt Lake to San Francisco.

Freight rates, at the end of 1948, on shipments of slack coal from the inter-

Table 11 . . . Freight Rates on Slack Coal to West Coast Points

In Effect December, 1948

Destination	Rock Springs, Wyo. Distance Miles	Rock Springs, Wyo. Use: Marine Bunkers	Rock Springs, Wyo. Use: Domestic	Castle Gate, Utah Distance Miles	Castle Gate, Utah Use: Marine Bunkers	Castle Gate, Utah Use: Domestic
Seattle	1,152	$5.04	$5.35	1,269	$5.04	$5.65
Portland	974	5.04	5.15	1,093	5.04	5.45
San Francisco	975	5.04	5.95	1,024	5.04	5.95
Los Angeles	1,026	5.04	6.45	928	5.04	5.95
Earnings in Cents per Ton Mile on Above Freight Rates						
Seattle	1,152	0.437	0.464	1,269	0.398	0.446
Portland	974	0.518	0.529	1,093	0.460	0.497
San Francisco	975	0.517	0.610	1,024	0.493	0.580
Los Angeles	1,026	0.491	0.630	928	0.543	0.642

mountain region to West Coast points for domestic consumption and for export are shown in Table 11. There is considerable disparity in rates from both Rock Springs, Wyo., and Castle Gate, Utah, to the four coast cities where the slack coal is to be used for purposes other than export. The rate on coal to be exported is the same from either starting point to any of the four coast cities even though there is a difference of as much as 341 miles in the shipping distance.

It is interesting to note that the freight rate between Sunnyside, Utah, and Fontana, Calif., on coking coal is $5.05 per ton and that coal up to 8 in. can be moved on this rate if it is suitable for coking. This rate was published late in 1942 on a contemplated annual movement of more than 500,000 tons.

There have been decreases in freight rates since 1923 on movements of slack coal from Utah into Seattle and Portland due to pressure on the railroads and to greater quantity of coal shipped.

It is the author's opinion that a movement of slack coal in excess of 3 million tons of coal per year from Utah to any point in central California would justify a freight rate equal to that published for Fontana, Calif., or $5.05 per ton.

The movement of 3½ million tons of coal per year on the basis of 240 mine working days per year would require that 14,600 tons be handled each mine working day. If it is assumed that shipments could be arranged for a 6-day week, the average railway movement would be 11,200 tons, or approximately 3 trains containing fifty-five 70-ton coal cars per day.

Such movements of coal would require railroad equipment represented by the investment amounts stated in Table 12 and entail the services of 250 men.

Table 12 . . . Railroad Equipment and Investment Required To Move 11,200 Tons of Coal a Day from Utah to California

Railroad Equipment	Cost
2800, 70-ton coal cars at $6,000 each	$16,800,000
32 locomotives at $310,000 each.	9,920,000
Miscellaneous equipment..........	5,000,000
Total..........................	$31,720,000

It therefore appears that, under presently known mining methods, the lowest price at which coal could be sold f.o.b. the mine in amounts of 3½ million tons per year for generation of power in central California would be $4.60. It also appears that the lowest freight rate that could be expected between intermountain points and the central California area would be $5.05 per ton, making a total cost of coal delivered at a plant site of $9.65 per ton.

Conclusions

The following are the author's conclusions:

1. Coal mines in Utah and in the Kemmerer and Rock Springs districts of Wyoming could increase annual production by 6½ million tons per year.
2. Under present conditions coal could probably be delivered to any steam electric plant in central California at a price not to exceed $9.65 per ton.
3. The use of coal at such a price, while higher than the equivalent present price of fuel oil, is entirely feasible.
4. There are adequate railroad facilities for movements of large quantities of coal from the intermountain region to the West Coast.
5. In a national emergency it probably would be extremely difficult, if not impossible, to obtain sufficient oil to meet requirements of the greatly expanded West Coast steam electric generating capacity.
6. The intermountain region contains ample coal reserves to supply all conceivable demands for West Coast power generation for a number of generations.
7. Increasing demands of labor threaten to lessen, if not eliminate, savings in cost of coal production through the use of new mining machinery.
8. Continuation of experiments in socialism by the Federal Government through construction of hydroelectric generating plants, particularly those unrelated to land-use reclamation, defies justification. Rates under this concept of a governmental function are subsidized through greater taxation of its people. Private capital is available to construct steam plants, or hydro plants where feasible, and should be permitted to continue in order to preserve the principles of our free enterprise system.

DISCUSSION

(L. C. McCabe and Robert P. Koenig, presiding)

C. G. Ball*—I was asked to lead off the discussion, but it is not with the thought that I might be able to add anything to the paper. The thoroughness with which it was prepared rather forestalls the asking of many questions. Your treatment, Mr. Heiner, is a very valuable contribution. I do want to suggest—that although you have limited your study to this specific question, with certain geographic limitations, many of the things in your paper apply just as well to the eastern coals. I want to agree 100 pct with your final conclusion concerning government-subsidized construction.

* Paul Weir Co., Chicago, Ill.

L. C. McCabe*—It is certainly worthwhile to take stock occasionally to see where we are going in problems of this nature. I agree with Mr. Heiner that ultimately the only reliable source of fuel that the West Coast has is coal but the time factor is the difficult element to evaluate.

Just before I came here I discussed this subject with N. B. Hinson, Vice President and Executive Engineer of the Southern California Edison Company, and Chairman of the West Coast Inter-Power Exchange Committee. He has given much thought to utilities' fuel supply and it was very helpful to me in preparing a discussion of the paper to talk with him beforehand.

Stock taking and forecasting of future development are essential to the continuing success of any enterprise. Mr. Heiner has called attention to the unprecedented growth of central and southern California and to the increased demands for fuel and power which have accompanied it. He discusses the increased fuel oil and natural gas requirements and the probable limits on the future use of these fuels and of hydroelectric power. In contrast to the calculable limits of these sources of electric energy, the author points to the availability of enormous reserves of coal in the Rocky Mountain States adjacent to the Pacific Coast which can be utilized for power generation. That there will be increased use of coal for power generation in the area under discussion is generally accepted but it is in the timetable of such development that there is not complete agreement.

In a recent report, Mr. Hinson reviewed the future power outlook for the Pacific southwest area. He pointed out that the use of steam plants in connection with water power plants in this region has made the maximum use of hydroelectric energy possible, and that the correct balance between hydro and steam generating plants produces the most economical overall system. Steam plants in the area which had been installed to protect against deficiency in hydro energy in dry years were used to carry war loads. Fortunately, no dry

* U. S. Bureau of Mines, Washington, D. C.

years occurred during the war so that in spite of the many new industries which moved into the territory, practically all demands were met. The construction of housing as well as the expansion of industry were major activities after the war. All of this activity created more load which made additional capacity necessary. Due to the shorter time of getting steam plants in service, the greater part of the additional capacity is provided by steam.

Mr. Hinson reported that the present installed capacity of the Pacific southwest power area at the end of 1947 was:

Hydro	3,300,000 kw
Steam	1,800,000 kw
Total	5,100,000 kw

The additions on order and under construction in the area for the years 1948, 1949, and 1950, amount to approximately 930,000 kw of hydro, and 1,050,000 kw of steam, or a grand total of additions of 1,980,000 kw. By the end of 1950 the total installed capacity will be:

Hydro	4,230,000 kw
Steam	2,850,000 kw
Total	7,080,000 kw

These additions are scheduled as follows:

Year	Kilowatts
1948	1,106,000
1949	163,000
1950	700,000

It is estimated, discounting war peaks and the present high rate of growth, that the electric load will double in 18 or 20 years, or by approximately 1965. Mr. Hinson indicated that on the Colorado within economic transmission distance of southern California, are located the proposed Bridge and Glen Canyon hydroelectric projects. These two sites have a capacity of approximately 1,300,000 kw as shown by some of the preliminary studies. There is approximately 400,000 kw of hydroelectric capacity that can be developed, in southern California and approximately 1,000,000 kw of generating capacity in northern California. To supply the 3,500,000 kw of additional generating capacity will require an additional 800,000 kw of steam after all available hydro is developed in the area. This additional steam capacity with that now in existence and under construction would make a total of approximately 3,500,000 kw.

It is concluded that more steam capacity may be necessary to provide adequate protection against low water years and that this increased amount of steam capacity will require large quantities of fuel. As Mr. Heiner points out, all of these steam plants are designed to burn oil or gas, and the more modern ones are designed so that with a minimum of change in the boilers and with the addition of special equipment, they could use pulverized coal.

The study for the Pacific Southwest Power Interchange Committee concludes that when the load in the area has doubled, practically all the additional generating capacity needed to carry the new load from that time on will have to be supplied by fuel burning plants. The possible use of atomic energy in the production of electric energy is discussed briefly. It is pointed out that if this form of energy should be used in modern steam plants, it will only be necessary to replace the existing boilers and fuel-burning equipment by atomic piles and their auxiliaries producing steam. This would mean replacements valued at 25 or 30 pct of the present investment in existing steam plants.

The prediction of declining petroleum production in the '20's and the subsequent expansion of that industry, suggest caution in estimating production potential of the petroleum industry. Within the past two weeks the price of fuel oil for power generation has declined 20 cents per barrel. Whether this trend will continue over a period of years cannot be foreseen but it does emphasize the present state of uncertainty in the whole fuel market.

It may be carrying speculation a little far to anticipate any appreciable use of fissionable minerals for power in the immediate future but it should not be ignored.

I note that in a paper given yesterday in the Oil and Gas Division, it was pointed out that the recent dieselization of railroads on the West Coast is a material factor in the fuel oil problem. It was stated that a diesel locomotive requires between a fourth and a third of the amount of oil that oil-burning locomotives consume. This has made more fuel oil available quite recently and within the past few weeks has contributed to the upset of the fuel oil market on the West Coast. That is a short-term trend, perhaps, but it is a factor and one that needs to be kept in mind in any study of the market position of the fuels.

Mr. Heiner has contributed a valuable paper which will be stimulating to the coal industry of the Rocky Mountain States and the power industry of the Pacific Coast. Studies of this nature are essential in planning the development of industry to serve the country in time of peace or national emergency.

C. P. Heiner (author's reply)—Mr. McCabe mentions the possible development of the Bridge and Glen Canyon hydroelectric projects by the government, having a potential capacity of 1,300,000 kw. In my opinion, the construction of such projects—unrelated to land use reclamation—cannot be justified, as electric rates under this concept of a government function are subsidized through taxation. Private capital is available to construct the necessary electric capacity, either steam driven or hydraulic driven, where feasible, and should not, by government action, be precluded from doing so.

V. F. Parry*—I found this paper extremely interesting and very thorough. The author and his staff are to be congratulated on this very thoughtful piece of work. From my point of view it seems conservative. The figures that Mr. Heiner uses are quite safe, I would say. A study of trends of electric power for the United States as a whole indicates that there is approximately a 50 pct increase each ten years. The author shows a 70 pct increase for the West Coast area, which is entirely consistent with the increase in population. The planning in reserve coal that would have to be blocked out for such power generation is necessarily affected by the increased power consumption.

In going over the paper, I noticed that gross Btu is used for comparison of energy in the form of coal and oil. I believe that the use of the net heating value would show a more favorable picture for coal. For instance, in well-engineered plants, the net heating value in relation between fuels can be obtained fairly accurately, and if this method of comparing fuels on a net heating value basis were used, the price of oil, calculated in the paper as \$2.62, compared with \$9.65 for coal, becomes about \$2.50. It decreases the spread of 18 pct that now exists and I believe will make a more favorable picture for coal.

I was glad to have the author mention the need for storage of coal, because that has been foreseen as one of the only solutions of bringing coal to the West Coast. The load factor on coal produced in the Rocky Mountains varies in a ratio of about 3½ to 1 between summer and winter months. If large quantities of coal were shipped here, it would require storage, which can be done. It would also alleviate the intermittent mining in Utah and Colorado which, I believe, would tend to cut the cost of coal considerably.

Eugene McAuliffe†—Next to food, fuel, whether coal or liquid, is the foundation stone of western world economy. To this end we should not fail to maintain a strong and readily expansible fuel industry. Mr. Heiner has shown the limitations of our western hydroelectric source of energy. Such should be expanded, where it is economically possible to do so, but I am not sure that he has sufficiently stressed the blighting effect of an extended cyclical drought, that would cut deeply into the supply of hydroelectric power.

As Mr. Heiner has suggested, the coal production of the west has suffered from the rapid substitution of diesel for coal-burning locomotives and that impair-

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† Omaha, Nebraska.

ment is steadily going forward. Without attempting to "view with alarm," I am wondering where the western railroads and industrial users of fuel oil for steam making purposes would get a substitute coal supply if war, or a threat of war, should result in a government mandate to cease the use of oil for making steam.

What the safety of the fuel supply of the West most needs is a strong coal industry, with the greatest possible substitution of machinery for hand labor and, in many instances, the development of improved housing near the mines, with other props, such as adequate school and recreation facilities, that will stabilize mine labor insofar as possible. We must keep in mind that our western railroads, largely depend on single track movement of freight and passengers, which tends to slow freight traffic, making added coal cars necessary. The railroads, under the pressure of oil competition, have made heavy investment in tank cars, with the result that for the first time in years, coal cars have been very scarce. Perhaps it is time to begin to buy gondolas rather than tank cars. The storage of coal at destination should be developed and encouraged, and somehow coal mining labor and their leaders must be shown that when our national economy needs fuel, it must be mined and moved without interruption.

C. P. Heiner—Mr. McAuliffe has presented some very worth-while and arresting reflections. First, a cyclical drought would have a crippling effect on high load factor industries dependent on hydroelectric power. It should also be noted that hydroelectric plants are no better than the water supply they depend upon. The simple expedient of building dams and hydro plants will not guarantee the supply of power to the vital industrial plants of the West. More and more steam plants must and will be built to make good the inevitable shortages of power produced by hydro plants. This applies to the Pacific Northwest as well as to California.

Second; I agree with Mr. McAuliffe that a healthy coal industry is our best industrial insurance policy in case of war or threat of war. A national policy of oil and gas conservation would aid in maintaining a healthy coal industry.

Third; information is at hand to indicate the railroads now have sufficient motive power and gondola cars to move at least 2,000,000 tons per year from Utah and Wyoming mines to the West Coast. Thus, both transportation facilities and mine capacity are ready to permit immediate extensive use of coal in large West Coast steam plants.

G. H. Cady*—This paper is very interesting. The author has presented a good case for the Utah-Wyoming coal industry as a source of fuel for the California utilities. I suppose the most critical consideration is the matter of reserves as discussed on pages 391 and 394 to 396 including the rate of recovery.

It is generally acknowledged that the present data on reserves is unsatisfactory. I think it is particularly so when presented in the form of maps. These suggest that the quantity of coal in various areas is indicated by the relative sizes of the areas. In general it is much easier to map the extent of the "coal measures," that is, groups or formation containing coal beds, than to map the actual extent of the area underlain by workable coal beds. For example, the area of the Eastern Interior Province in Illinois, Indiana, and Kentucky in which the Pennsylvanian "coal measures" are present can be readily indicated. It is much more difficult to indicate the area underlain by workable beds, which is considerably smaller.

Furthermore the idea of what constitutes a workable coal bed is changing from year to year. Forty years ago a 3 ft bed would have been regarded as unquestionably workable; hence the use of 14 in. as a minimum thickness of workability. This thickness did not seem unreasonable as it may today. Mining in a 3 ft bed on a commercial scale seems to be a thing of the past. In fact, in certain regions—the Middle West and the Rocky Mountain region—the limit seems to be about 4 ft.

To return to the matter of maps: What is true of Illinois, Indiana, and Kentucky I suspect is true of the western states, that is, areas mapped represent the extent of the Cretaceous and Tertiary "coal measures" and are therefore, too large to represent the actual extent of workable coal beds, which have not yet been accurately mapped. It is probable that the present tendency would be to mark off as very doubtful "reserve" the areas which are designated on the author's maps as "doubtful" that is with broken-line patterns. One wonders what conditions exist that make these areas doubtful.

Reappraisal of the coal reserves (p. 394) is certainly desirable but reappraisal is possible only on the basis of facts relative to the occurrence, distribution, and characteristics affecting mining of the different beds. Somehow there seems to be a feeling that the mere acknowledgment of the desirability of reappraisal will do the job. As a matter of fact, in many areas information about the coal resources is little if any better than it was forty years ago and the guess at that time would be matched by a guess today. The results, if different, would be so mainly because different criteria of workability were used. What is needed is a resumption of the coal-resource surveys that were carried on by the Federal government. These were largely abandoned before the war.

In regard to recovery (p. 395), I am surprised that the author's recovery is as good as reported. The estimate of 8000 tons per acre of surface area is, I believe, better than prevails in Illinois even in Franklin County where 7000 tons is the usual figure given by engineers, and it will not do to examine *that* figure too closely. This is, of course, all room-and-pillar mining by which method 99 pct of our coal is now extracted.

Our mining people seem to think that the new continuous mining machines are going to answer some of their problems but the items mentioned on p. 396, except possibly No. 2 seem to be valid. From what I have seen in Illinois I would say that success in their use depends very largely in having them work in pairs and continuously. They do a wonderful job. Judgment on the value of the machines will have to be deferred until they have passed the experimental stage.

I shall be interested to hear the reaction to this paper, the main thesis of which seems to be that Utah and Wyoming provide the logical sources of solid fuel for the California utilities, and as such, deserve certain concessions in regard to coal land ownership, control, and freight rates. It appears logical that if the railroads can afford to move export coal and coking coal for $5.05, they can afford to move other coal. I do not know how much of an issue will be made of the reserves problem, but it seems to me a rather critical one and that 25 years is altogether too short a time to look ahead —or is the author uncertain about this atomic energy business?

C. P. Heiner—Dr. Cady brings out the need of stressing the importance of considering the areas underlain by workable coal beds rather than the areas containing simply "coal measures." There is a great deal of so-called "coal land" in Utah and other intermountain states containing coal measures that likely can never justify mining operations. There are many miles of poor coal outcrops within the so-called "coal lands" and much exploration and geologizing must be done to determine the extent of any recoverable coal beds in such land.

In Carbon County, Utah, where the pitch of the coal beds is often 8 to 10 pct, a few mines have operated in 40 in. of coal. Frequent splits and/or areas of poor roof make such operations extremely costly so that a 4 ft bed is generally assumed to be the practical low limit of thickness. This same condition is also known to exist in Colorado.

I heartily agree with Dr. Cady that any reappraisal of western coal reserves should mean a resumption of coal-resource surveys that were formerly carried on under the U. S. Bureau of Mines. These surveys will also likely require much systematic core drilling some distance back from the coal outcrops.

Dr. Cady raises the question as to the propriety of assigning only 25 years of coal reserves to steam generating plants.

* Illinois State Geological Survey, Urbana, Ill.

That period was assumed as an absolute minimum life for modern steam plants. Government imposed acreage limitations make it difficult to assign at the outset a 25 year supply of coal for a large steam plant.

I am not too much impressed by the threat of atomic power plants doing away with the value or need of coal reserves.

M. G. Bluth*—The author has presented some very interesting and original data, opinions, and observations on a subject which has had little if any publicity, and which has extremely important implications in the economy of the western parts of the United States during periods of peace in the years ahead. In an emergency of national and international scope, the author's analysis would bear close study by both industry and Government authorities charged with maintenance of protection of the West Coast and the necessity of making power available for production of essential materiel in time of military operations.

The author has assumed that the fast growth in population in California will continue for some years to come. This appears to be a reasonable and fair assumption when the record for the past 20 years is examined—and especially since the start of World War II, during and since the end of that war. The population has increased in California to an amazing extent in the past few years and population increases of this proportion create and accelerate the growth of industry and commerce. The obvious demand, then, for power for industry as well as domestic use, to serve the growing industrial areas of California, means that fuel availability, water resources, and other physical elements in the generation of power and electricity stand as most important factors in order to meet any and all requirements under such a trend.

The paper did not emphasize, or perhaps to state it in a more direct way, it did not point out too clearly the need for extraordinary storage capacity to take care of the huge reserves of coal on the Pacific Coast (California) which would be most necessary and vital in periods of extreme national emergencies, as well as to safeguard against strikes of miners, railroad and transportation strikes, and acts of God. Both standby plants and extra heavy storage piles of coal would be necessary at plant sites in order to overcome the handicap of distance and other natural barriers. It seems prudent, under world conditions of unrest, to "play safe" in providing both the storage facilities and the standby plants, particularly in strategic locations where industry and the safety of workers and citizens are so important to the economy as well as assuring productivity in times of war.

While the author states that, in the interest of simplification his discussion is confined to the central part of California, it would be desirable to devote considerable study and attention to southern California. This region is enjoying a much faster rate of growth in population and is becoming increasingly more important as a center of industrial activity. Because this region was not included in the paper, questions naturally arise as to what major differences exist between central and southern California power requirements and problems; and if coal should prove to be essential to power generation on the Pacific Coast, what are the physical factors prevalent in southern California as compared to other sections of the state?

The author presents a brief diagnosis of Government hydroelectric power projects in the early part of the discussion. More emphasis could have been placed on, and the fact stressed that, Government projects are tax-free and as such private power enterprises cannot compete. Government hydroelectric power projects, on the other hand, could not compete with privately operated power companies if such Government plants paid their full share of taxes.

In one paragraph the author mentions the Colorado River power possibilities. His contention could have been strengthened if he had said that in addition to the high cost of constructing transmission facilities from the river to the Coast, the cost of transmitting power in such long distances is very high and the power losses are great—at least in the present stage of the art and development of transmission lines.

The author briefly covers the importation of gas and oil into California. Reference could have been made to the fact that utilities receive a much higher rate for gas sold to domestic consumers. Gas utilities, generally, take on large industrial and process gas users to provide an outlet in off-peak periods at dump load rates and as soon as they are able to build up a volume of business and demand for gas from domestic users, they soon drop their interest in industrial users except at the usual noninterruptible rates. Under such procedure, gas is not a practical fuel for year-round use in electric generating stations, but some uses can be provided for gas in such stations during off-peak periods and perhaps as a standby fuel in periods of emergency when the regular fuel is not immediately available.

No attempt has been made to analyze the portions of the author's presentation relating to coal reserves, mining costs, production, and other related matters. The particular part of the problem under discussion appears to be adequately covered pending more detailed and penetrating surveys which probably would be necessary in the event of a sudden demand or need for large quantities of western mined coal on the Pacific Coast.

In planning for national defense and military alertness, it is essential that the coal reserves and production possibilities and potentialities of the coal bearing and producing states of the Far West be given the careful attention of Government authorities and private enterprise, as one of the important factors in making our Pacific shores a strong bastion of both protection to the nation and the economic welfare of the national community.

The author has made an important contribution to a better understanding of the economic problems and fuel problems in the West. The paper, on the whole, should receive widespread attention and careful study of all those engaged in the field of power, national defense, and economic stability.

C. P. Heiner—The author stated in the paper that to deliver coal at the lowest possible cost on the West Coast, advantage should be taken of low mine production during the non-heating season which would entail storage of coal at points of consumption during those months. He does not agree with Mr. Bluth that any more coal would have to be stored on the West Coast during a national emergency or for protection against strikes than at any other part of the country. The author arrives at this conclusion because of the availability of several railroads between mines and points of consumption. He also does not agree that any more standby generating plants would be needed on the West Coast than any other coastal regions of the United States.

The author agrees with Mr. Bluth in regard to construction by the government of certain hydroelectric projects. He firmly believes in western land reclamation and, where generation of electric power is a proper adjunct to land-use reclamation, he believes that the most feasible method of power generation would be for private industry to construct the generating plants at the government dams, pay for the use of falling water and pay taxes on its operation. He does not agree with the concept that the government should construct generating plants and transmission lines on practically an interest and tax-free basis and compete with private, tax-paying free enterprise as such a concept is socialistic.

The author agrees with Mr. Bluth that even though large quantities of natural gas will be imported into California, its availability for continuous industrial use will probably decline not necessarily because of the higher monetary yields from domestic and commercial customers—such customer classifications consume gas at lower load factors than industry—but because of probable future actions of regulatory bodies.

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Discussion*

Contents

* TP 2695 ABFH.

A—Metal Mining

Alluvial Tin Mining in Malaya

By A. D. HUGHES, Member AIME

DISCUSSION

(*C. M. Romanowitz and K. Fritz Eilers, presiding*)

C. W. MERRILL*—Mr. Hughes' paper not only is very well presented but is most timely in that it covers a subject of vital interest to the United States. Tin is one of the strategic metals which has not been found here in appreciable quantities. The total United States tin output since the first recorded production over 100 years ago would not supply current consumption for a fortnight. On the consumption side, tin is extremely important in national defense because of its use in tin plate which, in the form of tin cans, makes it possible to feed properly the armies that the United States recruits from its civilian population in emergencies. Moreover, the internal combustion engines so important in powering tanks, planes, and other war machines, require large quantities of tin alloys for bearings and for soldering. These considerations, along with the fact that Malaya, historically, has been the leading source of tin to the United States, make the kind of information that Mr. Hughes has presented so ably, a matter of vital interest.

Your Chairman, Mr. Romanowitz, in his introduction, referred to the fact that I had been a member of the United States delegations to the three meetings of the International Tin Study Group. Some comments on the Group's objectives and deliberations may be of interest.

When it appeared that the International Tin Committee, the prewar producer's cartel, might soon revive its operations and extend its control agreement beyond the expiration date of Dec. 31, 1946, the United States Government became interested in some kind of an international trade organization concerned with tin which would give the consumers' interest equal representation with the producers' interests. An international meeting was called in London in October 1946 to consider this problem. I did not attend that meeting but the result of the meeting was the organization of the International Tin Study Group which

* U. S. Bureau of Mines, Washington, D. C.

called its first meeting in Brussels for April 1947, which I attended as a member of the United States delegation. At that meeting the tin supply situation was studied and a permanent Tin Study Group Secretariat was agreed upon to be headquartered in the Hague.

A second meeting of the Study Group was called in April 1948 in Washington, D.C., where again I attended as a member of the United States delegation. This meeting reviewed the tin supply situation. Among other items placed before the Group was a request by one of the delegations that the Tin Study Group proceed immediately to determine the advisability of an international conference to negotiate a commodity agreement under the International Trade Organization Charter. A working party met in the Hague in June 1948 to consider this problem.

A third meeting of the Tin Study Group was called for October 1948 at the Hague where again I was a member of the United States delegation. The report of the working group was considered. The Tin Study Group requested its delegations to report back to their respective Governments on the Group's deliberations and to request their Governments to inform the Tin Study Group Secretariat whether the negotiation of a commodity agreement for tin under the Havana Charter of the International Trade Organization was appropriate at this time. The Hague deliberations of the Study Group had developed a tentative framework for such negotiations. The reports by the various Governments as to their wishes with regard to such negotiation are now being received by the Secretariat. The closing date for reporting is now some two weeks off.

Drilling Blastholes at the Holden Mine with Percussion Drills and Tungsten Carbide Bits

By ELTON A. YOUNGBERG, Member AIME

DISCUSSION

(Guy N. Bjorge and Lynn Hersey, presiding)

J. H. HEARDING, Jr.*—Extremely hard ferruginous chert (taconite) was encountered in driving a drift at the Fraser underground mine near Chisholm, Minn., on the Mesabi Iron Range. In order to get better results in drilling in this ground, it was decided to try tungsten carbide bits.

In the beginning, 1⅛ in. tungsten carbide bits and 1⅛ in. round-lugged alloy steel drill rods with "jack-stud" inserts were used. Considerable difficulty was encountered because the jack-stud became loose in the drill rods. Because there was not enough alloy steel drill rod on hand, we began to insert jack-studs in the ordinary high carbon drill rods and found, to our surprise, that there was less trouble with jack-studs working loose in these rods than there had been with the alloy steel rods. As a result, use of the alloy steel rods has been discontinued entirely.

Under the heading "Drilling Procedures" the statement is made that all holes are started with detachable bits or conventional steel to prevent undue strain on the tungsten carbide bit inserts when collaring a hole on uneven ground. This practice was followed in our work originally for the same reason. It was soon found, however, that the holes could be started with the tungsten carbide without injuring the inserts if the drill operator was careful and did not give the drill too much air until the bit had a chance to seat itself in the rock.

* General Superintendent, Oliver Iron Mining Co., Hibbing, Minn.

J. C. FRANZ*—In a discussion of other technical papers with reference to percussion drills and the use of carbide tungsten bits, it was my impression that the authors reported one of the first difficulties experienced with the use of standard, conventional percussion drills, was insert bit failures due to crushing of the bit inserts when the bits became dull.

During the past few years, some of the rock drill manufacturers, I am told, have adopted an air drill for use with the carbide bits that have a lighter blow and faster rotation than the regular machine. This machine has been tested and the carbide bit failures have been considerably reduced.

L. W. DUPUY†—The difficulties Mr. Youngberg mentions that were had with rod and coupling breakage call to mind similar troubles experienced at the Picacho mine in California near Yuma.[8] The commercial couplings then available were found to be tempered almost to brittleness. Rod breakage was usually in the threads near the end of the rod. The highly-tempered couplings would break as soon as the rod broke. The solution was to thoroughly anneal the couplings and to put in only a very mild temper. Subsequently the alloy used in making the couplings was changed from the original by the manufacturer, but still only a very mild temper was used. The result was that the softer coupling would give but would not snap and release its hold on the broken rod thread. Fishing jobs were reduced to the few where the rods broke at the rod end of the thread. Thread breakage on the rods was further reduced by thorough annealing prior to tempering.

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† U. S. Bureau of Mines, Rolla, Mo.

[8] Leon W. Dupuy: Sampling the Picacho with Drill and Vacuum Collector. *Eng. and Min. Jnl.* (Jan. 1940).

The data Mr. Youngberg presents regarding the use of carbide inserts on long blasthole drilling is most interesting and it would appear that the use in this manner of percussion drills and carbide bits will have many applications.

W. M. WOODWARD*—How many feet of hole, on the average, do you get from a tungsten carbide bit, and is there much variation from this average?

E. A. YOUNGBERG (author's reply) —In recent months the 2 in. tungsten carbide bit footages in long hole drilling have varied from 115 to 140 ft monthly. The footages obtained from individual bits vary from several feet to over 300 ft, however the life of a majority of the bits will be within 25 ft of the average.

* The Cananea Consolidated Copper Company, S. A., Cananea, Son., Mexico.

Diamond Drilling Quartz-feldspar Intergrowths

By L. C. ARMSTRONG, Member AIME

DISCUSSION

(Guy N. Bjorge and Lynn Hersey, presiding)

A. E. ROSS*—Mr. Armstrong in his paper stated that they had experienced considerable difficulty in drilling the quartz-feldspar intergrowths. The diamond loss was excessive and the diamond bits polished quite rapidly.

Mr. Davidson, who presented the paper, stated that bortz stones in the range of 20 to 30 per carat had been used in the bits on this job. I would like to suggest the use of bits employing stones in the range of 60 to 100 per carat, an average of possibly 80 per carat. If these stones had been used the bits might have lasted longer and not polished so quickly.

As a basis for this suggestion I would like to point out that in northern New York State we had at least two examples where bits employing stones in the range of 80 per carat had solved a difficult problem. Bits set with stones in the range of 20 to 30 per carat had been used previously and had failed. With the finer stones, the cost per foot of drilling decreased materially.

It should also be noted from a technical standpoint that the smaller stones require higher drilling speeds than the larger stones. Greater pressures are not normally necessary, and it is the higher speed which seems to be the major factor of importance.

It should also be noted that the finer stones afford a greater number of cutting surfaces for the same carat weight in a bit. Then too, the smaller stones, by virtue of their size, serve as sharper cutting edges than larger stones. There is no doubt that the diamond bit employing smaller stones costs more to set than the bit using larger stones. However, with the technique developed at the shops of Sprague and Henwood, Inc., we feel that the relatively slight additional cost required to set these bits is more than paid for by the resultant lower drilling cost. We feel that the highest quality stone available is the most economical to use when hard fine grained rock is encountered.

In summary, I would suggest that it might be possible to solve the problem presented in this paper by using a diamond bit employing stones at least as small as 80 per carat of the highest grade possible and by using the diamond bit at the highest speed available with modern drilling equipment.

L. C. ARMSTRONG (author's reply) —It is generally agreed that the use of smaller, high-grade diamonds and of higher drilling speeds, as suggested by Mr. Ross, may be the best approach to the solution of the problem.

* Assistant to President, Sprague and Henwood, Inc., Scranton, Pa.

Safety Practices at the Crestmore Mine of the Riverside Cement Company

By R. H. WIGHTMAN and G. H. ADAMS, Members AIME

DISCUSSION

(L. A. Walker and H. C. Weed, presiding)

H. C. WEED*—Referring to the use of "dummy fuse" for checking the shots in chute blasting operations, I believe that an even better practice is to blast the chutes with no delay electric blasting caps.

Permanent wires can be strung through the grizzly lines and the lead wires from the shots attached to these lines. Using this method, no time is lost in spitting the individual fuses. The possibility of a fused charge becoming dislodged by previous shots and falling into the chute below is eliminated and there is no chance of a man walking back into his own blast.

A small hand twist blasting machine or a radio "B" battery can be used to fire the shots if the lines are fired individually. If so desired the entire area can be blasted at once by a switch at the manway or in the drift below, providing a sufficient source of electricity is available. In case a switch is used, proper precaution for locking the switch must be provided.

R. H. WIGHTMAN (author's reply) —We do use electric blasting when the number of shots is large; but we have found it more satisfactory to use fuse and caps for individual shots on the grizzly.

* Inspiration Consolidated Copper Co., Inspiration, Arizona.

B—Minerals Beneficiation

Effects of Rod Mill Speed at Tennessee Copper Company

By J. F. MYERS and F. M. LEWIS, Members AIME

DISCUSSION

C. G. McLACHLAN*—I have read this paper with considerable interest and wish to congratulate the authors on the care with which they carried out their experiments and for the detailed sizing data they have presented. On the other hand I do not feel that these data establish their contention that "with other factors the same, the work accomplished in a fine crushing rod mill is directly proportional to the rotating speed."

My reason for making this statement is that their conclusion is based on the percentage of minus 65 mesh material produced at each of the speeds at which their tests were run.

The rod mill is, however, not a fine grinding machine and therefore figures based on minus 65 mesh production are figures outside the range at which it operates to best advantage. Further, if rod mill performance is to be judged on the production of such material it should have been established that a rod mill will produce it as effectively as a ball mill.

* Noranda Mines Ltd., Noranda, Que., Canada.

To check this last point I have gone over some of the rod and ball mill grinding figures for our Waite-Amulet operation and find that the ball mill at that property produces more minus 65 mesh material per horsepower than the rod mill. Moreover, this comparison is even more favorable to the ball mill if it is limited to minus 100 mesh production.

It therefore seems to me that the most satisfactory basis on which to try to compare the performance of the rod mill in the present case is by taking a weighted average of all the new surface produced per horsepower.

W. H. Coghill[1] has published data which can be applied to the sizing figures presented by the authors, and if this is done the units of new surface per horsepower produced in the Tennessee tests are as follows:

Critical speed, pct.	82.4	74.6	70.5	66.5
Units of surface produced per hp.	1.000	1.014	1.023	1.027

[1] W. H. Coghill: Evaluating Grinding Efficiency by Graphical Methods. *Eng. and Min. Jnl.* (1928) 126, (24) 934.

Admittedly the increment of increase in new surface per horsepower shown in the foregoing figures is not great, but its trend is nevertheless definitely in favor of slower speed operation, for the conditions under which these particular tests were run.

I also feel that some information regarding liner contour should have been given as I think it will be found that a mill which is equipped with liners which lift the rod load can be run at a slower speed than a mill in which the liners are comparatively smooth.

J. F. MYERS and F. M. LEWIS (authors' reply)—The position taken by Mr. McLachlan is to be respected even though we are all aware of the faults of surface considerations. As he points out, the increment of increase is very small. It is so small in fact that for all practical purposes it does not conflict with the conclusions of the paper. The authors appreciate Mr. McLachlan's comprehensive study of the data.

Humphreys Spiral Concentration on Mesabi Range Ores

By WHITMAN E. BROWN, Junior Member AIME, and LOUIS J. ERCK

DISCUSSION

(*I. M. LeBaron and F. R. Milliken, presiding*)

L. A. ROE*—This paper is one of great value to the iron ore industry. The Humphreys spiral is a relatively new tool and gives promise of being quite useful in solving certain problems of iron ore beneficiation. Spirals have been tested on a martite ore at the Benson mine of Jones and Laughlin Steel Corp. in northern New York State. Our New York ore is considerably different, physically and mineralogically, than the one mentioned in this paper, and contains only 25 pct iron. This ore can be processed on spirals to give a concentrate containing 62 pct iron with an 85 pct recovery. On our particular ore we found operating difficulties when the spiral feed was coarser than 14 mesh. These were chiefly due to excessive "build-up" of locked middlings in the spiral circuit. In extreme cases these middling particles would accumulate to such an extent that the plant had to be shut down and the spiral surge tanks cleaned out.

It is interesting to note that there exists a close relationship between the results of tabling a given iron ore and concentration of this same ore on Humphreys spirals. The size range of the ore must, of course, be within those limits acceptable to spiral concentration. Comparative tests on several of our martite ores showed tabling results to be the same as spiral results.

The authors make no mention of the use of a tailing stream splitter (now available from the spiral manufacturer) which is a useful tool in studying iron losses in the tailings stream. On our particular martite ore we found a considerable accumulation of fine-sized iron ore particles in the outside portion of the tailings stream. This fraction may be amenable to further treatment.

* Jones and Laughlin Steel Corp., Negaunee, Mich.

E. H. ROSE*—The authors have concluded an interesting piece of work and this paper is an excellent factual account of a rapid and somewhat unusual transition in practice in the plant described. Perhaps it was modesty on their part which caused them so casually to limit to one sentence the fact that "several other methods of concentration on the fine ores representative of the Hill Trumbull group . . . failed to produce consistently an acceptable grade and recovery of finished product." The fact is that they were confronted by a difficult mineral-dressing problem and they are to be congratulated on their courage and persistence in staying with it until a satisfactory solution was evolved. A visitor to the plant might have been mildly astonished, as I was, to see one type of concentrator handling that part of the load early in the 1947 season, its experimental replacement by another a little later, and then in 1948 to see that both types had simply disappeared and their place taken by the spirals which were operating as placidly as though they had been there all the time.

* Tennessee Coal, Iron and Railroad Co., Birmingham, Ala.

In working out economic methods of beneficiating Alabama red ore, most of which development is still ahead of us, it is likely that we also will pass through a period of successive disappointments, for we too have a problem where it is next to impossible either to "guess 'em right in the first place," or, because full-scale operating cost is such an important factor, to lay the ultimate answer on the line in advance by means of laboratory experimentation.

Iron ore being what it is instead of what it used to be, it is encouraging to have the example the authors have given us today that a tough nut that will not crack on the first blow or the second is apt to do so on the third or fourth.

Jaw Crusher Capacities (Blake Type)

By D. H. GIESKIENG, Member AIME

DISCUSSION

E. H. BRONSON*—I find this paper very interesting, except that I am not able to understand the derivation of the so-called "realization factor."

* Consulting Metallurgical Engineer, Toronto, Ont., Canada.

This factor is defined as the ratio of the size of square opening passing all the feed to the gape of the receiving opening. By this I presume the author means the size of rock feed to the width of crusher opening. So if we fed a 12 in. rock to a 16 by

24 in. crusher, the ratio would be 16/12.

However, this does not seem to be the case. On page 245, under the heading of Crusher No. 1, he has a theoretical factor of 1.00, with a feed of −24 in. and a jaw opening 36 in. wide.

Another point, on the same page he converts capacity of a 60 by 48 in. crusher, to a 10 by 7 in., treating hematite. With the large crusher the weight of material fed is 155 lb per cu ft, but with the smaller crusher the weight shrinks to 100 lb per cu ft.

A clear explanation of these two points would assist in reading an otherwise interesting paper.

D. H. GIESKIENG (author's reply)—In regard to the derivation of the "realization" factor, *r* outlined in the paper, the equation exclusive of *r* represents the maximum choke feed capacity of a crusher at given values of speed, setting, width, throw, and so on. The realization factor, *r* introduces the limitations imposed by hang-ups of the feed characteristic of the various practical means of feeding the crusher.

One of the probabilities of these hang-ups concerns the relative size of the larger pieces in the feed and the size of the crusher receiving opening. As a criterion of this the ratio of the size of square opening passing all of the feed to the gape of the receiving opening was employed. If a minus 12 in. rock is fed to a 16 by 24 in. crusher, the ratio would be $^{13}/_{16}$ or 0.75. From Fig 1, an average performance or "realization" of about 90 pct would be expected for well designed feeding systems, and about 50 pct for the other extreme; *r* would be either 0.90 or 0.50, respectively.

In reducing realization factors from field data it is necessary to calculate the maximum capacity of the crusher by excluding *r* and then compare this with the tonnage actually obtained. The curves shown on Fig 1 were calculated from available data.

On page 245, under the heading of Crusher No. 1, the factor 1.00 refers to the nip-angle which is 26°.

Fig 5, 6, and 7 have been used for two purposes. The first was to reduce the 10 by 7 in. laboratory crusher data to terms of the effect of setting and feed factors upon capacity. In doing this it was necessary to adjust these data to common conditions of feed density (100 lb per cu ft), stroke (0.65 in.), and speed (250 rpm). Secondly, these curves were used as a convenient means of comparison of data from larger crushers in the field. To draw this comparison as in Fig 5, the results obtained with the 60 by 48 in. crusher had to be revised to what capacity would have been obtained had the feed weighed 100 lb per cu ft instead of 155, the speed been 250 rpm instead of 163, and so on. Also, since the comparison was made at an equivalent 10 by 7 in. setting of 3 in. it was necessary to convert the nip-angle effect from 25° to 18°. Based upon 3 pct per degree this factor becomes 1.21.

It is hoped that the foregoing will help to interpret the paper. Your interest is appreciated.

F—Coal

Sampling of Coal for Float-and-sink Tests

By A. L. BAILEY and B. A. LANDRY, Member AIME

DISCUSSION

W. W. ANDERSON and G. E. KELLER[*]—We want to compliment the authors on this very thorough paper. It gives information which the coal industry has needed for some time. We hope that the additional information which the authors are collecting will be available shortly.

The mixing and riffling procedure that was followed for experimental purposes is obviously not practical in routine float-and-sink testing because of the particle size degradation which would result in handling the sample so many times. It is important to obtain our float-and-sink fractions with a minimum amount of handling of material.

A statement is made in the paper (p. 80) that "the variable most likely to affect the size of sample required to meet a given preassigned accuracy would be the state or degree of mixing of the coal." We agree that this is a large factor, but do not believe it is the most important factor. Our own opinion is that the most important single factor governing the total gross weight of sample that must be collected is the percentage of the weight of material in the smallest fraction that results from the screening and float-and-sink operations. In other words, size of sample is governed by the total number of fractionations that must be made, and the distribution of material within the fractions.

We can imagine a coal with perfect mixing, but with such a small amount of material in some float-and-sink fraction in one of the coarse sizes that a much larger sample would have to be taken than would be the case with very poorly mixed material, but with a large percentage of coarse material more evenly distributed in all float-and-sink fractions.

Our own observation of many float-and-sink tests that we have run in our own organization on many types of coal is that the size of sample that must be used on fine size float and sink is governed more by the requirements for weight of material to be used for analysis in the laboratory than by weight of material necessary to obtain accurate float and sink percentage of weight values. In other words, it is our opinion that very small samples can be used for float-and-sink fractionation in the fine sizes, but that accurate analysis of the fractions will depend on a larger weight of sample being pulverized for the laboratory than is necessary to establish the float-and-sink distribution with respect to weight.

* Commercial Testing and Engineering Co., Charlestown, West Va.

A. L. BAILEY and B. A. LANDRY (authors' reply)—The authors thank Messrs. Anderson and Keller for their comments based on long experience. It is agreed that the involved mixing and riffling technique used may be disadvantageous from the standpoint of degradation. Fortunately, the paper does point out that the extended riffling was unrewarding in causing further mixing. Two large unknowns remain, however: (1) how much of the mixing from the presumed highly unmixed state in the bed was achieved toward the random state during blasting, loading, transportation, screening, and further transportation to the point where the gross sample was taken, and (2) how much of the mixing took place during the preparation described preceding riffling. As has been pointed out by one of the authors,[5] the degree of mixing has a very large effect on the size of sample required and there are still too few experimental data to show at what stage of coal handling most of the mixing occurs.

The discussion states that the weight of material in a screened fraction, or in a float-and-sink fraction, is more important than the mixing factor. We do not believe that these factors are comparable in this instance inasmuch as our purpose was to give minimum sampling requirements to achieve a preassigned accuracy in the percentages of float, middlings, or sink, and nothing more. The gross sample had already been screened and no further division by screening was made or contemplated; also, it was not intended that the middlings and sink fractions would necessarily be adequate for percentage ash or other determination. In other words, the sample obtained by the method outlined is not intended for washability studies but only for preparation plant control. Further experimental work has been done, since the paper was prepared, to investigate the effect of increasingly larger top and bottom sizes on the variability of float, etc., of a double-screened coal from Western Pennsylvania. Results will be published and eventually attention is to be given to the preparation of sampling specifications.

[5] References 5 to 10 are at the end of this discussion.

E. H. M. BADGER[*]—I should like the authors to explain more fully the fundamental assumptions on which their Eq 4 is based. The equation is of the form

$$\sigma^2 = p(1 - p)$$

which is the usual expression for the (standard deviation)^2 when the chance of finding a particular kind of particle in the sample is proportional to the number fraction, p. But instead of the number fraction, the authors have used the weight fraction, $\frac{W_F}{W}$. The chance of finding a particular kind of particle in the sample can only be proportional to the weight fraction, if the average *weights* of all kinds of particles, that is, float, midlings, or sink, are the same. Surely a much more justifiable assumption would be that the average *volumes* of the particles are the same, and, if this is so, Eq 4 would not be true.

This may be demonstrated as follows: Let w be the weight fraction of float, middlings, or sink, d_1 the density of this fraction, and d_2 the density of the rest of the coal. Then assuming that the average volumes of the pieces in the three classes are the same, the number fraction, p, is given by

$$p = \frac{\frac{w}{d_1}}{\frac{1-w}{d_2} + \frac{w}{d_1}} = \frac{wd_2}{d_1 + w(d_2 - d_1)} \quad [5]$$

The weight fraction, w, in terms of p is given by

$$w = \frac{pd_1}{(1-p)d_2 + pd_1} = \frac{pd_1}{d_2 + p(d_1 - d_2)} \quad [6]$$

* North Thames Gas Board, London, England.

Suppose that all the pieces of the float fraction are thought of as balls of one color and weight, while those of the middlings are of another color and weight, and those of the sink are of a third color and weight, but that the size of all the balls is the same. Then on taking samples out of a heap, the *number* of balls of one color can be noted and expressed as a fraction of the total. The (standard deviation)^2 of the number fraction will be given by

$$\sigma_p^2 = p(1 - p)$$

or on a percentage basis

$$\sigma_p^2 = p(1 - p) \times 10{,}000$$

But if the *weights* of balls of one color are noted and expressed as a fraction of the total weight, the (standard deviation)^2 of the weight fraction will not be the same as that of the number fraction, because the addition of one ball of the sink to the sample makes more difference to the weight fraction of the sink than the addition of one ball of the float makes to the weight fraction of the float.

The relation between the two standard deviations, i.e., that on a weight basis, σ_w and that on a number basis, σ_p is given by

$$\sigma_w = \frac{dw}{dp} \sigma_p$$

dw/dp can be obtained by differentiating Eq 6

$$\frac{dw}{dp} = \frac{[d_2 + p(d_1 - d_2)]d_1 - pd_1(d_1 - d_2)}{[d_2 + p(d_1 - d_2)]^2}$$
$$= \frac{d_1 d_2}{[d_2 + p(d_1 - d_2)]^2}$$

This can be written in terms of w by substituting for p from Eq 5

$$\frac{dw}{dp} = \frac{[d_1 + w(d_2 - d_1)]^2}{d_1 d_2}$$

From the relations between p and w, it can be shown that

$$p(1 - p) = \frac{dp}{dw} w(1 - w)$$

Therefore we can write

$$\sigma_w^2 = \left(\frac{dw}{dp}\right)^2 \cdot p(1 - p)$$
$$= \frac{dw}{dp} \cdot w(1 - w)$$

If the second form of the equation is used, it is not necessary to calculate p in order to find σ_w^2. The equation represents the (standard deviation)^2 of the weight fraction. If the (standard deviation)^2 of the percentage by weight is required, as in the paper by Bailey and Landry, the value must be multiplied by 10,000.

The application of these results to the Western Pennsylvania coal may be now considered. It is necessary to assume values for the mean densities of each fraction. The densities of the rest of the coal were obtained by calculation on the basis of these assumptions:

	Float	Middlings	Sink
Density of fraction	1.30	1.50	2.20
Density of rest of coal	1.75	1.365	1.325
Weight fraction	0.7705	0.1257	0.1038
dw/dp	1.192	1.074	1.526
σ_w^2 (percentage basis)	2,108	1,180	1,420

The values of the (standard deviation)^2 are substantially greater than those given by the authors, the biggest difference being for that of the sink fraction. The points should presumably be plotted against the average weight of each respective fraction and not against the average weight of the whole coal. A point that arises here is the way in which the average should be calculated. Would the authors explain why they use a simple average for float-and-sink tests but use a weighted average weight for ash?

A. L. BAILEY and B. A. LANDRY—The authors are grateful for Mr. Badger's comments on the two important points raised in his discussion.

Eq 2 of the paper is applicable strictly only to a coal whose pieces are of the same weight and, similarly, Eq 4 is applicable only when the pieces are considered to be of the same weight in which case it is of the same form as the binomial $\sigma^2 = p(1 - p)$, given by Mr. Badger, since cumulating on the weight is then equivalent to cumulating on the number of pieces.

Mr. Badger correctly points out that because pieces of sink material may have a density as high as 2.2 whereas pieces of float may have a density as low as 1.3, corresponding pieces having the same volume may have a weight ratio of 2.2/1.3 or 1.7 with a corresponding inverse ratio of the *number* of pieces offering themselves to random choice. However, Mr. Badger could have pointed out, even more forcefully, that because the size range for the bituminous coal was 1⅛ in. by No. 4, the weight ratio of the largest piece to the smallest piece, when both are of the same density, was 91, and for the anthracite of the order of 116. The effect of these ratios on choice, and on the number of pieces per increments of a given weight, far outweigh the small effect of differences in density.

These departures from theoretical requirements were recognized, but it was nevertheless assumed that Eq 2 and 4 might apply because of the compensating effects of the smaller and larger pieces when the variability of pieces or of increments is referred to their average weight. The general concordance of the results shown in Fig 3 and 4 indicate that this assumption was warranted.

Accurate calculation of the variance associated with the curve of Fig 2 would not be practicable if consideration were given to the size range as well as to the density range of pieces. On the other hand, if sampling specifications are ever prepared to cover this phase of coal sampling, a simple method must be available of calculating the variance of the single (average weight) piece from rough knowledge of the percentages of float, middlings, and sink in the coal to be sampled. This means using Eq 4 as given.

In this connection, it is hoped, of course, that from the general knowledge of the size consist of coals mined from a given bed by a specified method, it will be possible to compute the average weight of piece against which the calculated variance will be plotted. On the assumption that the size consist is the same for float-and-sink material, the average weights used may be related in the ratio of their mean densities before plotting. However, the resulting small displacements on log coordinates would probably be well within the errors of the broader assumption made on size consist and, again, we preferred to use the simpler method of not correcting for density in view of the eventual application to coals of uncertain size consist.

The second important point raised by Mr. Badger has to do with the reason for use of the simple average weight in this paper, whereas, in published work on coal sampling for ash, one of the authors has used the weight-weighted average weight.[2]

Eq 2 when expressed as Eq 1 is applicable to a coal whose pieces are not of uniform weight. The average weight of piece to be used in this instance is the weight-weighted average weight. This can be calculated if the size consist of the coal is known. For a small range in size, the difference between the weight-weighted average and the common average is small; if the size range is wide, however, use of the weight-weighted average is almost mandatory. In this paper, the common average was used primarily because no data were available on the size consist and, moreover, the size range was considered narrow enough to justify using the simpler expression, again having in mind the eventual preparation of general sampling specifications.

J. VISMAN*—The following notes refer to the basis of the theory dealt with in the paper. *Page* 79, *col.* 3, *line* 9: "At present there are no published standards for float and sink test sampling." Three years ago the British Standards Institution published a specification for screen analysis of coal (other than pulverized coal) for performance and efficiency tests on industrial plant.[4]

* Central Laboratory, Staatsmijnen In Limburg, Geleen, Netherlands.

Page 81, *col.* 2, "*Particle count*" *etc.*: The calculation of the weighted mean particle (the authors report to have measured the average weight of particle), would be simplified when using the sieve analysis and applying the formula

$$V = \frac{\Sigma qi \cdot d^3}{\Sigma qi} \qquad [7]$$

where V = weighted mean particle volume.

q = weight of sieve fraction, percent (so $\Sigma qi = 100$).

d = average diameter of sieve fraction.

This formula is directly related to

$$\overline{w} = \frac{\Sigma w_i^2}{\Sigma w_i} \qquad [8]$$

which may be shown as follows.

Multiply Eq 7 by the average specific gravity (γ), then substitute

$$q_i = \frac{100 w_i n_i}{W} \quad \text{and} \quad d_i^3 \gamma = w_i$$

From this it follows

$$V \cdot \gamma = \overline{w} = \frac{\Sigma n_i w_i^2}{\Sigma n_i w_i} = \frac{\Sigma w_i^2}{\Sigma w_i}$$

From experiments (carried out at the Dutch State Mines) it has been found that coal particles of a sieve fraction $(d_1 - d_2)\Phi$ may under laboratory conditions, be considered within narrow limits as cubes with sides $d_{12} = \frac{(d_2 - d_1)\Phi}{2}$.

In case round sieve-holes are used, the particles of a sieve fraction $(d_1 - d_2)\Phi$ may be considered as cubes with sides

$$d_{12} = \tfrac{1}{2}\sqrt{2}\,\frac{(d_2 - d_1)\Phi}{2} = 0.7\,\frac{(d_2 - d_1)}{2}\,\Phi$$

according to the ratio between the side of a square and the diameter of the circumscribed circle.

The ratios given here are valid under laboratory conditions only.

The weighted mean particle volume of a coal may be computed accurately and quickly from the size-consist data, provided the coarse fractions are kept within narrow limits.

Thus the weighted mean particle weight ($\overline{w}$) too may be determined directly from the size-consist data, without the use of a planimeter, the Rosin-Rammler equation, or even the counting of particles.

Page 82, *col.* 2, "*Calculation of* σ_w^2": In the formula for the variance (σ_w^2) the influence of the specific gravity has not been mentioned.[6] As the accuracy of a specific gravity separation is as a rule expressed by the accuracy of the smallest fraction (by weight), one might make use of the following formula.*

$$\sigma_x^2 = 100\,\frac{x \cdot \gamma \cdot V}{W}$$

σ_x = standard deviation of (x) in percentage of (W).

x = weight of smallest fraction in percentage of (W).

γ = specific gravity of fraction (x).

V = weighted mean particle volume in (cu cm Φ).

W = weight of sample, grams.

which is valid where $x \leq 10$ pct, and on the understanding that there is no segregation (to be used only when reducing a gross sample under laboratory conditions). In case of sampling segregated coals, there should be added a variance (σ_s^2), which is proportional to the rate of segregation (B) of the coal, and to the number of increments (N) as follows:

$$\sigma_s^2 = \frac{B}{N}$$

As the influence of the analysis on the accuracy is negligible as far as specifications are being strictly adhered to, the ultimate variance (σ^2) may be formulated as follows

$$\sigma^2 = \sigma_x^2 + \sigma_s^2$$

$$\sigma^2 = 100\,\frac{x \cdot \gamma \cdot V}{W} + \frac{B}{N}$$

where W = weight of gross sample in grams.

B = variance of (x) due to segregation.

N = number of increments (for $x \cdot \gamma \cdot V$ see above).

This formula is valid if the gross sample is analyzed as a whole, without reducing its weight. If on the other hand the gross sample (W) would be reduced in weight to (W_1) grams before analyzing, another variance (σ_r^2) would have to be added

$$\sigma_r^2 = 100\,\frac{x \cdot \gamma \cdot V}{W_1}$$

So, $\sigma^2 = \sigma_x^2 + \sigma_s^2 + \sigma_r^2 + \ldots$

If the process of splitting would be repeated, again a variance $(\sigma_r')^2$ would have to be added, etc.

The variances σ_r^2, $(\sigma_r')^2$, $(\sigma_r'')^2 \ldots$ form a convergent geometric series, the sum of which tends quickly to a limit with increasing number of subdivisions

$$\bar{\sigma}_r^2 = 200\,\frac{x \cdot \gamma \cdot V}{W_{min.}}$$

Here ($W_{min.}$) is the final weight of the sample intended for analysis. So the total standard deviation follows from:

$$\sigma^2 = 100\,\frac{x \cdot \gamma \cdot V}{W} + \frac{B}{N} + 200\,\frac{x \cdot \gamma \cdot V}{W_{min.}}$$

$$= \frac{A}{W} + \frac{B}{N} + C \qquad [9]$$

Here A, B, and C are constants for a given product, at a given method of sample reduction.

Page 84, *col.* 3 *line* 5: "The general agreement . . . gives confirmation to Eq. 2 and justifies its use in establishing sampling characteristics of coals for determination of float and sink values; and, incidentally gives added confirmation to the use of the similar Eq 1 in coal sampling for average ash."

From the mathematical point of view there is some doubt about the validity of the "mixing exponent."

If the above-mentioned Eq 9 is expressed in the form of Eq 2 of the authors, we find:

$$\sigma_W^2 - \frac{B}{N} = \left\{100x + \frac{200\,W \cdot x}{W_{min.}}\right\}\left(\frac{W}{\overline{w}}\right)^{-1}$$

Plotted on a log-log diagram there ensues a straight line slanting under 45° from the point ($\overline{w}$, $\sigma_{\overline{w}}^2$) as long as the influence of the segregation $\left(\frac{B}{N}\right)$ and of the subdivision of the total sample are negligible as compared with (σ_W^2). In other words, from the mathematical point of view a curve may be expected which starts from the point ($\overline{w}$, $\sigma_{\overline{w}}^2$) as a straight line under 45°, and which will be bent up slightly at the lower end, as a result of the influence of the segregation and of the reduction on the total variance ($\sigma_{\overline{w}}^2$).

The same conclusion is valid for ash determinations. Here the formula for (σ_W) is[6]

$$\sigma_W^2 = \frac{A}{W} + \frac{B}{N} + C$$

A/W = variance due to size consist and ash distribution.

B/N = variance due to segregation.

C = variance due to reduction and analysis.

Putting this formula again in the form of Eq 1 of the authors, we find:

$$\sigma_W^2 - \frac{B}{N} - C = \frac{A}{\overline{w}}\left(\frac{W}{\overline{w}}\right)^{-1}$$

From this it follows theoretically, that, as long as $\left(\frac{B}{N}\right)$ and (C) are small in comparison with (σ_W^2), the curve on the log-log diagram will start rectilinear at point ($\overline{w}$, $\sigma_{\overline{w}}^2$), sloping at 45°, bending upward at the lower part. In our opinion therefore, the extrapolation by means of straight lines does not correspond with the theory of probabilities.

It is expected that if the data mentioned in the publication under consideration are being reconsidered from this point of view, correcting the weighted average weight of particle and its variance ($\sigma_{\overline{w}}^2$), a similar picture will be obtained.

From experiments carried out at the Dutch State Mines it was found that the

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* Mentioned earlier in a different form by Kassel and Guy;[7] for derivation see ref. 8

factor $\frac{A}{\bar{w}} = \frac{A}{V\gamma} = \sigma_{\bar{w}}^2$ ranges (for the ash determination) from 0 — ca 2000, a value much higher than the variances found by Landry,[10] while (B) ranges from 0 — ca 200.

$\left(\frac{A}{V\gamma}\right)$ is closely related to the ash-content, whereas the variance (B) depends on the form of the washability-curve as well as on the method of cleaning (compare products of jigs and heavy-medium washers).

Evidently, the variance ($\sigma_{\bar{w}}^2$) can never be measured directly from a multiple-size product, because the smallest sample which may be considered as representative for that product should have a weight equal to at least several times the weight of the coarsest particle, that is (for a product corresponding to the formula of Rosin-Rammler) about 10 (as an order of magnitude) times the weight ($\bar{w}$); so the variance (σ^2) only has real meaning for values less than about 200.

There remains much to be said on this subject, particularly with respect to the influence of small samples on the accuracy and the question of bias.

In our opinion it is possible to draw up specifications for the sampling of coal and ore (for the analysis of several constituents, size consist and specific gravity separation), based on the principles mentioned above. The ultimate form in which these specifications are given, may be very simple. In the case of ash determination for instance, it is possible to express the weight of sample and the number of increments directly as a function of the total ash-content and of the maximum particle size, at a given accuracy.

The experimental work needed for these specifications may be restricted to a minimum. The main difference between these specifications and those now in use is that the number of increments would be considerably higher, whereas the minimum weight of increment would be diminished—in extreme cases—to several times the weight of the coarsest particle.

A. L. BAILEY and B. A. LANDRY—The authors are in agreement that the extended remarks of Dr. Visman are directed toward the published works on coal sampling of the junior author of the paper rather than at the paper itself.

Dr. Visman's Eq 7 for the weighted mean particle volume would appear to have considerable merit except that it substitutes a step-wise process for the continuous process which results from use of the Rosin-Rammler equation or the planimeter method; thus, a somewhat larger number of screen sizes should be required for the same accuracy. In planned experiments this can be achieved but in using available information from commercial operations fewer than enough screen-size data can be expected as a rule.

Eq 9 is well known to the junior author as it has been suggested or used by a number of statisticians concerned with sampling. Data have not been presented in the literature, however, to show that it will apply; that is, that A and B will remain constant, when the variance of the percentage ash of coal is determined experimentally for increments of increasingly larger weights, with the understanding that these are to be reduced to laboratory size by a process that involves crushing of the entire increment before riffling or quartering. Upon such data depends ultimately the choice of formula for the variance.

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Synthetic Liquid Fuels from Coal

By J. D. DOHERTY, Member AIME

DISCUSSION

A. R. POWELL*—Mr. Doherty has outlined in a most thorough manner valid arguments for the development of an industry in this country making synthetic liquid fuels from coal. No thoughtful person will dispute the statement that it is essential to carry on fundamental and applied research and acquire engineering "know-how" by the erection and operation of two or three large plants in the near future. Considerations of national security indicate that this should be done, irrespective of any temporary present surplus of natural petroleum.

It is the belief of the discusser and of many others interested in coal technology that our energy picture of the future will include an increasing utilization of coal directly, without any conversion to liquid fuel, as a source of energy. A fact that is sometimes forgotten is that petroleum fuels have often been cheaper than coal in many locations and over long periods of time, and this price factor has been of great importance in expanding the use of petroleum fuels at the expense of coal. Synthetic liquid fuel made from coal must necessarily be several times as costly as the coal from which it is made, and this fact alone will have a profound effect on the future energy pattern of our country. This complete change in the economic relationship between solid and liquid fuels will lead to the substitution of coal itself for many uses now supplied by the relatively cheap petroleum fuels.

From the standpoint of conservation of our natural resources, the substitution of coal itself for liquid fuels wherever possible when the age of synthetic liquid fuel arrives is also logical. At least 50 pct of the energy of coal is lost during conversion to liquid fuel. Nor is this compensated for by a higher utilization efficiency of the liquid fuel in most cases. For example, modern steam-boiler plants can operate at equal fuel efficiencies with either coal or fuel oil.

* Koppers Co., Inc., Pittsburgh, Pa.

It seems to the discusser that Mr. Doherty has underestimated the curtailment of oil consumption that will accompany the future introduction of synthetic oil made from coal. Reduced oil supplies need not curb our economic advancement, as Mr. Doherty fears, provided proper research and development programs on improved utilization of coal itself as an energy source are carried out. Such programs should be given as much emphasis as the present synthetic-oil programs in the interest of conservation, national security, and economy in our fuel planning for the future.

Unless some revolutionary development now unforeseen occurs, liquid fuels will always be predominant for use in the various forms of internal-combustion engines and for certain specialized fuel uses, even though their cost is several times that of coal. For this reason it is important that much research and development on synthetic oil from coal be carried out ahead of the time that decreasing petroleum production and higher prices make the manufacture of synthetic oil necessary, and the Bureau of Mines is to be congratulated on its foresight in aggressively following such a program. Despite the belief expressed above that direct substitution of coal will cause curtailment in liquid-fuel use when the synthetic era arrives, the discusser also thinks that the synthesis of liquid fuel from coal will prove to be one of the major developments in this country during the next decade or two.

An Evaluation of the Performance of Thirty-three Residential Stoker Coals

By JAMES B. PURDY and HARLAN W. NELSON

DISCUSSION

C. F. HARDY*—When a new mine is opened, there is always a question as to the suitability of the coal for various uses including domestic stokers. Until this service was offered by Battelle, it was customary to hand-screen a few hundred pounds of coal and distribute it among various engineers or other stoker users. Obviously, this is unsatisfactory and in no sense of the word standard procedure. There have been several instances where stoker plants were installed by this hit-or-miss system of evaluation, and the coal has proved unsatisfactory for use in domestic stokers after the plant was built. On the other hand, the Battelle standard evaluation tests, by showing that the coal was unsuitable or borderline, have prevented several companies from useless investment in stoker-screening facilities, and the cost of trying to promote the coal on the market.

This paper is particularly valuable in that it brings to the attention of the coal industry the fact that there is a method of testing available, which gives a reasonably accurate evaluation of a coal for domestic-stoker use before it is placed on the market. This should stimulate further research which should tell why coals perform as they do in domestic stokers.

R. J. HELFINSTINE†—The correlation shown between the laboratory combustion tests and the public acceptance of the coal is of particular interest. This type of information is needed to bridge the gap between the laboratory and the consumer.

This paper furnishes more evidence that "armchair philosophy" is often used to condemn good stoker coals. Obviously, no coal should be branded as unsuitable for domestic stoker coal because of high (or low) ash-fusion temperature, or high free-swelling index. Actual combustion tests are required to establish the clinkering and coking characteristics of a coal, and judgment should be based upon performance and not upon appearance.

The tests described in this paper show that a longer hold-fire period was required with high ash coals. This might be expected with the type of hold-fire control used for the tests. However, it is the writer's opinion that this relationship would not exist if the controls were of the time-interval type.

* Appalachian Coals, Inc., Cincinnati, Ohio.
† Illinois State Geological Survey, Urbana, Ill.

C. H. SAWYER*—The work described in this paper represents the longest-standing program of such research with which we are familiar, and all of us who are interested in this subject have borrowed freely both in ideas and in method from it.

Both R. I. Bush, Director of our Pittsburgh Stoker Research Laboratory, and the writer had an opportunity to examine this paper in advance and he shares with the writer responsibility for the following comment:

* Eastern Gas and Fuel Associates, Pittsburgh, Pa.

We liked especially the authors' careful statement that values of fuel-bed resistance indicate ". . . the general condition of the fuel bed." Certainly, fuel-bed resistance cannot be ascribed to any one property of the fuel bed, such as thickness, as is so often claimed. We think this error has led to many false starts on air-control design and it certainly finds its way into much stoker advertising. We think the limit of 1.5 in. of water given as maximum trouble-free fuel-bed resistance exceeds the capabilities of several stoker fans we have tested and would be safer set at some lower value, say, of the order of 1.25 in. Fortunately, there is a trend toward higher-pressure fans among stoker manufacturers, and the point will assume less weight as time eliminates the old low-pressure jobs.

The authors have questioned the temperature selected for hold-fire pickups in their method. We use an entirely different method of evaluating hold-fire performance. In typical stoker operation out fires are most likely to occur at some time between 3 and 5 hr after the last prolonged operation of the stoker. Many coals, particularly the semifluid types represented by some of the popular low-volatile stoker coals, will pick up very sharply after this low-activity period and would thus show an average time of hold-fire operation little if any below the normal, even though their remaining alive

may have been a touch-and-go proposition at the critical stage. We cannot, however, offer a completely satisfactory substitute for the method cited. We still use 3 min per hr timed operation as a hold-fire test. Most coals will hold fire at such a rate, and we think minimum activities, as indicated by stack-temperature records, give a closer indication of the likelihood of out fire than does the average reactivation time of the Battelle method. However, we pay for this policy with occasional out fires which means virtual inability to run a "standard" test on the coal in question since much other data of value are no longer reliable after rekindling such a fire. Possibly avoiding a hold-fire check until the end of a test schedule might overcome the objection to some such attempt to get a closer assay of hold-fire characteristics.

Mr. Bush has suggested that residual coke as determined is subject to too much accidental variation to allow significance by any means short of running several tests on each coal to obtain an average value. He does not feel that the size consist of residual coke is subject to as much variation as is the quantity, and suggests comparison of some figure such as average size of residual coke as an alternative attempt to index the likelihood of coke-tree trouble.

We find the lack of pattern in clinker data disappointing as did the authors. It seems that no test of such short duration can answer satisfactorily the question of "clinkerability." However, in our own laboratory we have noted a slightly better correlation of clinker removed with ash-softening temperature than that indicated in the graph shown. The writer has wondered considerably about this difference since he knows how carefully this work is done at Battelle. One possible partial explanation for the difference is offered:

Our fires are undisturbed throughout the entire week. In the tests under discussion clinker is removed on the evening of the fourth day. It would seem only human nature for an operator to search a fuel bed showing little or no clinker more thoroughly than one containing some obvious pieces at this stage of the test. Such search would constitute cultivation which is always of help in clinkering difficult ash. Thus certain high-fusion or otherwise difficult-to-clinker coals might be unconsciously thrown out of line in this performance characteristic by even the most conscientious operator. As a matter of fact even an equivalent degree of cultivation (unavoidably entailed in any clinker search) might favor high-fusion coals in this regard and tend to even the end quantities of clinker.

J. B. PURDY and H. W. NELSON (authors' reply)—Mr. Hardy has pointed out the economic advantages of a laboratory conducted evaluation test. This of course is of prime importance. In addition, one of the strong points in favor of a test method of this type is that it permits the evaluation to be made regardless of the season or of fluctuations in outside temperature. It also permits making a relative evaluation of coals with comparative ease, since consideration of variations in equipment is reduced to a minimum.

Mr. Helfinstine's comment regarding the type of hold-fire control used is correct. However, as pointed out by the authors in the paper, the method used does provide a relative means of comparing the performance of coals during the periods of hold fire, even though it must be recognized that the period of operation during each hour may be longer than necessary. The method eliminates interruptions occasioned by attempts to find the lowest possible hold-fire setting for each coal under test, yet it furnishes a relative measure of performance.

Mr. Sawyer's discussion of clinkering data is of special interest. Disturbing the fuel bed certainly has an effect on the subsequent formation of clinker in spite of all the care that is taken in handling the clinker tongs. However, when burning a high-ash coal at a feed rate of 30 lb per hr, as employed in these tests, sufficient ash has been deposited by the end of the fourth day to make it often necessary to remove the clinker at that time, thus insuring a relatively clean fuel bed for the intermittent heat-demand run of the last day of the test.

Some Aspects of Mechanical Coal Cleaning in Utah

By CARL S. WESTERBERG

DISCUSSION

(H. F. Yancey and Orville R. Lyons, presiding)

L. C. McCABE*—An increased demand for coal in the west is to be expected because of the growth in population and industry during the past ten years. The author calls attention to the increased mechanical cleaning of Utah coal between 1938, when no cleaning was being done, and 1947, when more than 24 pct of the production was cleaned. This is essentially the period of most rapid growth of the Pacific Coast area although the growth and, no doubt, the general trends in coal production and cleaning continued at a less accelerated rate during 1948. The Pacific southwest increased 27 pct in population between 1940 and 1947 while the United States showed only a 7 pct increase in the same period. It has been estimated that there will be an additional 15 pct increase in population between 1947 and 1950. The conclusion that more coal and more mechanical cleaning capacity will be required appears to be well founded.

Mr. Westerberg discusses the economic advantages of coal cleaning reflected in freight savings, in lower cost per million Btu, and lowered ash and sulphur content. In view of the limited occurrence of coking coals in the west it would be interesting to know whether significant beneficiation in coking strength can be expected from mechanical cleaning of Utah coals. This has been demonstrated for some eastern and midwestern coals.

One can readily agree to the desirability of recovering the fine coal that has heretofore been lost in washery slurry. The very cheapness of coal has hindered

* U. S. Bureau of Mines, Washington, D.C.

the development of fine coal recovery in the past but with improved fine coal recovery methods it is possible that recoveries of washed coal will approach the theoretical values of the washability curves.

In European preparation practice, fine coal is more widely recovered than in the United States. There are a number of reasons for this, some of which are that coal is generally more friable and fine coal recovery is essential, it is mined with greater difficulty and greater cost and commands a greater share in the price of finished products. Europe is geared to a coal economy and in the past oil has not been important for power generation and heating purposes. This is another way of saying that our very abundance of both coal and oil is responsible for this difference in recovery practice.

Coal Washing in Colorado and New Mexico

By J. D. PRICE and W. M. BERTHOLF, Members AIME

DISCUSSION

(H. F. Yancey and Orville R. Lyons, presiding)

A. C. RICHARDSON*—First of all, I think that the paper represents a lot more work, study, and correlation than has been indicated by the brief talk by Mr. Price. I like the way he started out and described the areas from which the samples were obtained, the locations of the washing plants, the available tonnages, and other background information with which to evaluate the data he submitted later on. Then I like the way in which he described the various types of washing plants, the tonnages handled and the difficulties of the washing problems; showing the amount of material that lies close to the specific gravity at which the washing separation is made. Later he gave figures from washing plant operations showing recoveries and cleaning efficiencies.

He then discussed his own plant at Pueblo. It is the same old plant, I think, that I worked around a good many years ago. It is unusual to find a plant treating nearly 5000 tons of coal a day on tables. But this table plant is, I believe, more efficient than is indicated by the figures that Mr. Price gave.

To determine the efficiency of a cleaning operation or to compare it with another it is necessary to consider the quantity and character of the material close to the specific gravity at which the separation is made. It is not fair, I believe, to penalize the table operation by something like 4 pct of out-of-place material as he has done here. The variety and difficulty of the coals that he has to wash, the continuous shift and change in their composition make a very difficult cleaning problem and the table performance is excellent.

I believe that the information in this paper will be of interest and value to anyone operating or planning to build a coal cleaning plant in this or other areas; particularly where the cleaning of fine coal is a problem. The data may be used for comparative purposes in determining the relative efficiencies of other cleaning plant separations.

* Battelle Memorial Institute, Columbus, Ohio.

E. D. HAIGLER*—What is a Baum jig?

J. D. PRICE (authors' reply)—A Baum-type jig is one in which the pulsations of the water is secured by means of a pulsating air current applied on top of the water. I imagine you are all familiar with the old plunger-type jig which is in effect a U tube in which a plunger on one side of the U, moving up and down, causes a corresponding pulsation on the far side of the jig. In the Baum jig, the pulsating air current is applied on the surface of the water on one side of the U tube of the jig and gives a corresponding pulsation on the other. It is also commonly known as a pneumatic jig. The control of the rise and fall of the water in the jig body proper is under much better control than it is in any of the other type jigs. Mr. Richardson could enlarge on that feature, for I know that he has had considerable experience with these jigs.

A. C. RICHARDSON—You have asked how to control a Baum-type jig. The pulsations in a Baum jig can be modified and regulated to a marked degree by the amount of water admitted to the jig and by the adjustments of the valve which regulates the manner in which air is admitted.

* The Foxboro Co., Kimberly, Nevada.

The number of pulsations per minute is controlled by the number of cycles of the air valve. Thirty to forty cycles per minute is a good speed for large jigs treating coarse sizes of coal.

With an air valve it is possible to modify the time-velocity curve of the pulsating water to some extent which in turn determines the action in a jig bed. Within limits the following parts of the air valve cycle may be regulated: (1) the rate and period of air admission, (2) the period of air expansion, (3) the rate and period of air exhaust, and (4) the period of air compression.

The rate and period of air admission determines the acceleration of the water at the beginning of the pulsion stroke and the amplitude of the stroke. The period of air expansion, after inlet port is closed, is one in which the water has reached the desired velocity, positive acceleration reduced, and the bed held in a mobile condition. The rate and period of the air exhaust can be adjusted to modify the degree of suction and so modify the manner in which the particles in the bed stratify. The compression period, after the exhaust port closes and before the intake port opens may be used to advantage in retarding the downward velocity of water during the suction stroke.

An ideal jig stroke is one in which during the up stroke the bed is lifted slowly in a mass and opens up like an accordian with the bottom layers dropping away first. With the bed open and mobile the particles adjust themselves according to their hindered settling rates. During the down stroke, while the bed is still open the particles of high specific gravity are accelerated toward the bottom layers. It is possible to approach this stroke with all types of jigs but it is less difficult to approximate it with a Baum jig.

C. S. BLAIR*—I would like to know what size coal is treated on these Plat-0 tables, and whether that had some bearing on whether they were less efficient than these Baum jigs. I have never heard anywhere that a table was not more efficient on fine coal than any type jig.

J. D. PRICE—The size we are now treating is ½ in. by 0 with no fines taken out ahead of the tables. The entire supply of coal is crushed to ½ in., and all sizes are treated on the tables. The reason that the tables are not as efficient now as in 1940 was shown on Table 18 which gives comparisons of washed coal for 1940 and 1947. The coal now contains such a great amount of impurities, such a great amount of "middling" gravity material, that the tables are considerably overloaded with reject material. As a result, it is impossible for the riffles to completely carry the middling material to the reject end and a considerable amount goes over the riffles into the washed coal.

The coal, coming as it does from twenty or more mines, varies considerably in quality and the tables can be adjusted only for the average quality of the coal. When the coal is of better quality than this average, good coal goes into the refuse; when it is of poorer quality than average, material which should be rejected finds its way into the clean coal. Hence the average overall efficiency of separation is not as high as might be desired.

C. S. BLAIR—You overload the tables?

J. D. PRICE—That is right. The coal is not suitable for high speed operation on the tables but we must run at a high capacity to get the required tonnage through.

* Black Diamond Coal Mining Co., Birmingham, Ala.

Coal Washing in Washington, Oregon, and Alaska

By M. R. GEER and H. F. YANCEY, Members AIME

DISCUSSION

(H. F. Yancey and Orville R. Lyons, presiding)

O. R. LYONS*—I know that we are all interested in hearing about problems that other people have. To most of the people from the eastern part of the United States, this kind of coal preparation is completely different. It represents washing difficulties that most operators have never experienced, or, if they have, they have refused to consider them because there are coals that are much easier to wash and, therefore, they leave the more difficult ones alone for the time being.

E. R. McMILLAN†—I think the authors have summarized the material very well. Dr. Yancey has spent a great many years in the study of washing coals, as has Mr. Geer. I might comment briefly on some of the plants that were mentioned, plants with which I have had some connection, particularly those of our own company, the Northwestern Improvement Co. I would like to point out this: that in each case, a great deal of work was done in the way of preliminary studies of washability of the coal before plants were built. The first plant of any size built in Roslyn field was mentioned in the paper. This central cleaning plant was designed and built to handle coal from three different mines. I might say that prior to 1935, the year in which the plant was built, the coal was used largely as railway fuel, close to a million tons annually. But as mining increased in depth, it became increasingly difficult to separate and gob much of the impurities underground, with the result that the run-of-mine coal became so high in ash that the railroad eventually was forced to consider installing some kind of preparation plant at the mine.

We spent about a year in preliminary studies in cooperation with the Bureau of Mines to find out the best type of plant that would clean the coal. The result, as Mr. Geer has explained to you, is a rather complicated plant, but it is doing a very satisfactory job. We have, however, made a number of changes and improvements since it was first built. The last addition was the installation of a centrifugal drier to dewater the minus ¼ in. size. We are now contemplating installing heat driers for further drying of minus ¼ in. We use Vissac heat driers for drying the stoker coal, the ¾ to ¼ in. The demand for drier coal, for both railway and industrial use, is forcing us to further drying of the coal.

The plant that was mentioned as having been built in Pierce County, during the war, was a government sponsored plant. I happen to have had some connection with its design, construction and initial operation. We did what we thought then, and still think, was a very thorough job of preliminary studies in cooperation with the Bureau of Mines on the coal from that field. The plant was as good a plant as could be built with the equipment available at that time, 1943. The plant that was mentioned as having been built at Ravensdale for treating the McKay coal was rebuilt about two years ago, and in addition to the modified Elmore jig washer that was mentioned, we added a concentrating table for recleaning the minus 3/32 in. Our object there was to produce a commercial

* Battelle Memorial Institute, Columbus, Ohio.
† Northwestern Improvement Co., Seattle, Wash.

stoker coal with an ash content of 5 pct or less.

W. M. BERTHOLF*—In the data shown on minus 3½ or minus 3 in. coal, there was one coal which was sized and data shown for various fractions from 1 in. down. It would appear that these coals are extremely streaky or laminated and would have to be crushed very fine in order to liberate the impurities. Is this the situation?

* Colorado Fuel and Iron Corp., Pueblo, Colo.

M. R. GEER (authors' reply)—That would follow for coking coal where the market would permit you to do such fine crushing; all steam or domestic coal cannot be reduced down to minus ¼. However, what you say is true; reducing the coal to that top size would give a higher yield at a lower ash content.

A Technical Study of Coal Drying

By G. A. VISSAC, Member AIME

DISCUSSION

(*Joseph Daniels and J. W. Woomer, presiding*)

O. R. LYONS*—I wish to thank Mr. Vissac for his compliment. I hope that his paper is not only well received, but that it will serve to bring forth more papers on the subject of thermal drying. One of the primary purposes of the work performed by Battelle for Bituminous Coal Research in investigating the thermal drying of coal was to stimulate other investigators and to get them to contribute their knowledge in the form of papers such as this one. We at Battelle and the personnel of Bituminous Coal Research are very gratified that Mr. Vissac and other persons have responded in this matter of the thermal drying of coal.

I wish to state that I think that Mr. Vissac's paper is a very clear and easily understood description of a method of calculating the design requirements for a screen type drier, and I think that it would be exceedingly valuable to operators and to those who intend to purchase any type of thermal drier and use it in the future, if the manufacturers or operators who have such information for other types of driers would provide the same type of information for the other makes of driers now on the market.

I also wish to point out—an idea that is new to me, and I know is new to most of the operators of driers in the United States—the idea of recovering the heat that is normally lost in the coal and in the exhaust gases. This heat is not being recovered at most of the thermal drying operations in the United States, and the possibility of recovering it should be called to the attention of every single one of those operators. I know many of them have never given any thought to the matter, but they will be interested once they realize the ease with which it could be done and the savings that could be realized.

* Battelle Memorial Institute, Columbus, Ohio.

I also wish to compliment Mr. Vissac for presenting the method of analysis that he uses to determine the difficulty of drying any particular coal. It is a very simple method, and yet it seems to me that it should be a very effective, very efficient method for determining the difficulty of drying for his particular problems.

C. P. HEINER*—I do not know that I can add anything very illuminating to what Mr. Vissac has said. I think anything that Mr. Vissac said in regard to coal drying is a contribution because, to my personal knowledge, he has studied the matter carefully for many years and made many valuable contributions.

I am not too familiar with coal drying problems in the east, but I know in the west we have not made enough coal drying studies. I think coal operators too often just take the coal as it is and make more or less the best of it. There are relatively few washing plants in the west now, and so the problem has not come to the front as much as it probably will in the future.

In this connection, it seems to me that this matter of drying the raw coal, as Mr. Vissac brings up, is an extremely important one. We have not a continuous miner ourselves, yet, but we expect to get some this year, and we think the percentage of fine coal—that is, minus 3/16 in.—will double. We have about 20 pct minus 3/16 in. in the 8 in. by 0 size now, and we think we will likely have 40 pct, which will have a surface moisture of the order of 8 pct. To wash it satisfactorily, we will have to dry the raw coal first in order to screen it, and after that, I suppose, there will have to be dry cleaning of some sort.

* Utah Fuel Co., Salt Lake City, Utah.

We have not really used dry cleaning on fines in the west yet to my knowledge, but it is a matter that has to be faced by the industry, and I am very hopeful that Mr. Vissac's study will assist us in that connection.

W. L. McMORRIS*—In my company we are preparing largely metallurgical coal for a great number of byproduct coke plants. The most outstanding thing to me about the requirements of moisture in the finished product is that there is a different requirement for almost every coke plant. Each operator has a different set of factors on which he establishes his coking costs where they involve moisture. For our corporation operations in Birmingham, my company does not produce the coal, but in Birmingham they are getting away with moistures very much higher than our plant at Clairton, Pa., would tolerate. The moisture that we have to produce for the plants along the lakefront where they are subject to much more severe weather is something else again. We have not tackled heat drying, primarily because our customers do not know what heat drying will do to the coking characteristics of the coal. If the temperature of drying can be held down

* H. C. Frick Coke Co., Pittsburgh, Pa.

to from 120 to 140°, it is hard to imagine that heat drying would affect the coking characteristics unless they were on the ragged edge to begin with.

The mechanical drying of coal has been given a great deal of study recently owing to the advent of the solid bowl centrifugal filter that has been installed in several plants and sold by the Bird Machine Co. of Massachusetts. Other filters of that same character, in smaller sizes, have been used widely in other industries. We have had some experience with the Bird filter and have found it desirable for the mechanical removal of moisture. They are efficient, but one of the outstanding reasons why it is, let us say, a desirable unit, is that it does give a mixture of all the sizes which are going to be put to that type of mechanical drying. In drying ¼ by 0 material the Bird filter cake contains all of the fine sizes. The handling of coal by vacuum filters and screen basket driers gives two fine-mesh products. Our experience with the Bird filter has been variable. Thirteen were recently installed in a plant but for our conditions we found it desirable to rebuild them. We had done some experimental work as to the most desirable bowl contour to secure the most efficient drying. We had formed that bowl contour with baffles making a coal bed. When formed with steel, the center section had an angle of about 19° with the rotating axis of the machine, and we found that the coal would not convey up that slope. It would hang until it was forced through. Instead of carrying a normal bed, it built up and would move by fits and starts. We put in what our men in the plant called "skid chains." We took the machines apart and put in conveying strips in the line of normal travel of the material to prevent its moving around the circumference of the bowl. We do not know yet how good a job of drying we are going to do. It has been irregular, but the whole operation of the new plant has been irregular, and we have not said yet that we cannot make a regular cake. We did have mechanical difficulties most of which are corrected.

Whether the Bird filter would put coal in the best condition for thermal drying is something we do not know. As I said before, our biggest problem is knowing what our various customers have to have in the way of a final product. I see there are some coke plant men here, and I would not be surprised if they have different ideas of what they need in their plants.

G. A. VISSAC (author's reply)—I think we agree entirely, at least that is what I tried to convey, namely: all possible moisture should be removed mechanically before heat drying. We have had some experience with mechanical driers, too. We have the centrifuge, but did not buy the Bird centrifuge because with our coal, it was not possible to reduce its moisture below 12 pct. In other words, the final moisture content that a centrifuge would be able to give varies so much with the kind of coal and the size composition, that it is very difficult to guarantee a moisture content.

When it comes to requirements, I am at the present time working on a new coke plant in connection with Simon Carves of England. They have a new design by which they claim the higher the moisture content, the better they like it. In fact, they want me to use 10 pct moisture, which is unusual as my experience has been that in coke preparation 6 pct was about the ideal. It is certain that with more moisture, even if the brick walls can carry it and if nothing is disturbed, time is required to evaporate the water. As it takes as much as 2 or 3 hr to evaporate the water, the capacity of the oven is reduced accordingly. In addition, we have not only to deal with coke, but have more to do with briquettes, which the railways are using. All the coal in the old country used by the railways is briquettes, because in this way there is a definite standard of quality, and it is easier to store.

To make a good briquette, the moisture cannot exceed more than 2 pct. That is where our drying problems become difficult. Railway specification at the present time on mine run, to show that moisture is far more important than ash, is as much as 16 pct ash, and less than 3 pct moisture. That is why we have to dry it.

The results of centrifuge driers in our country are that we are never able to get below 9 to 12 pct moisture. Coals freeze below 3 pct, so the centrifuge does not solve our problems.

Drying Low-rank Coals in the Entrained and Fluidized State

By V. F. PARRY, J. B. GOODMAN, and E. O. WAGNER

DISCUSSION

(*Joseph Daniels and J. W. Woomer, presiding*)

C. P. HEINER*—If you take out 35 pct of the total weight of the coal in the form of moisture, would that be about what it was in the case of North Dakota lignites?

V. F. PARRY (authors' reply)—That is about it.

C. P. HEINER—That will be about a 35 pct loss and the final product will be about 11,000 Btu?

V. F. PARRY—That is right. The heating value of the dried lignite is 10,000 to 11,000 Btu.

C. P. HEINER—And the thought is not, then, to produce a commercial coal with that heavy loss, but to make other products—that is, synthetic fuel base, is that it?

V. F. PARRY—The principal thought is to upgrade the coal, making it a more favorable raw material for industrial purposes, both for shipment and direct use. You see, the trouble in these lignites is that their moisture penalizes their

* Utah Fuel Co., Salt Lake City, Utah.

shipment, and if we can remove that at low cost, they can be shipped greater distances to industrial plants.

C. P. HEINER—The only observation I have to make is if you only raise it to 11,000 Btu you still have a vast quantity of reserves that are much hotter, as you well know.

V. F. PARRY—This is just the long range study of possibilities of these low grade coals, and raising them up to 11,000 Btu does not reach the quality of high grade coals yet.

The Rupp-Frantz Vibrating Filter

By W. M. BERTHOLF and J. D. PRICE, Members AIME

DISCUSSION

(Joseph Daniels and J. W. Woomer, presiding)

W. J. PARTON*—I have not had the opportunity to read this paper, and I do not have a written discussion. However, I thought it might be interesting for me to relate some of the experiences we had with equipment similar to the vibrating filter as described by the authors.

At the Tamaqua flotation plant of the Lehigh Navigation Coal Co. approximately 40 tons per hour of froth concentrate carrying 60 pct by weight moisture are produced. The major problem encountered at this plant is the dewatering of this coal froth so that a satisfactory product can be sent to market. In the original design of the plant a centrifuge of solid bowl type was included for dewatering this material. The centrifuge did not work out as well as we had hoped. High maintenance costs and moisture content in the cake were obtained.

A Robbins dewatering screen was installed at a later date with the idea of using it in conjunction with the centrifuge. The froth concentrate from the flotation cells was fed directly to the Robbins dewatering screen. The cake from the screen carried approximately 55 pct of the feed solids. Moisture in the cake was approximately 24 pct by weight. The underflow from the screen carried 45 pct of the feed tonnage at about 80 pct moisture by weight. The underflow product was then pumped into the centrifuge with the idea of using the centrifuge for recovering the tonnage lost through the screen. This circuit did not operate as satisfactorily as we expected. The only benefit derived was in the reduction in the power consumed by the centrifuge. The maintenance on the centrifuge was approximately the same as previously.

The next step in our experiments was to pump the underflow from the screen into a cyclone thickener which was mounted directly over the vibrating screen. This thickener increased the concentration of the solids to approximately 60 pct by weight and dropped the material back on the filter cake which had formed toward the discharge end of the screen. Unfortunately, the screen was not capable of handling this additional tonnage, and our experiments stopped at that point.

We have been considering installing a second screen to make possible the complete mechanical dewatering of this product by the use of the dewatering screen and the cyclone thickener.

Another possibility under study is to pump the underflow from this screen to a thickener which is available in the flotation plant, and to combine this thickened underflow with the original feed going to the screen. Again, however, a second dewatering screen will be required to handle the total tonnage.

O. R. LYONS*—I had an opportunity to read this paper ahead of the meeting, and I did a little pencil engineering on it. As Mr. Bertholf said, it is very difficult to make a comparison and to carry the results of work at one plant over to what might be expected at another. What I did was to find information on filtering operations more or less comparable to the type of operation that Mr. Bertholf has with his vibrating filter. The only information that I was able to find was for drum type filters, and I found the operating characteristics of the vibrating filter and the drum type filters were very similar. The moisture contents of the cakes were almost identical. The output per square foot was about the only way that I could compare their capacities—using square foot of screen area against square foot of filter area—and I found the capacity of the vibrating filter to be slightly greater per unit area than the capacity of the drum-type filters.

W. H. NEWTON†—Do I understand that the only escape for the solids is by overflowing the thickener? That is, does the filter have a chance to recover all the solids except that lost in the thickener overflow?

W. M. BERTHOLF (authors' reply)—Actually, the only escape from that part of the circuit is over the top of the thickener. There are other places the fines could be lost in the washery, but once they get into that part of the circuit, they must go over the top to escape.

W. H. NEWTON—I would like to ask Mr. Lyons if, in the study of rotary filters, he has any basis for comparison of operating costs?

O. R. LYONS—No, I had no information on costs. The only information I was able to find was on screen size, moisture content, and tonnage output per unit area.

W. L. McMORRIS*—Are you wasting that overflow water or re-using it?

W. M. BERTHOLF—Right now, we are not re-using it.

D. R. MITCHELL†—What is the approximate per capita cost of one of these units?

W. M. BERTHOLF—It appears to be somewhere in the neighborhood of $200, for the screen.

W. H. NEWTON—The cost would be about $2500 for the complete unit including the vibrating power unit.

G. A. VISSAC‡—I do not like to come on the floor after I have been talking so long, but I thought you might be interested in our experience in dewatering, as well as drying our very fine coals. We have used both centrifuge and vibrating screens. The type of vibrating screens we have used in Canada are called the Zimmer. That is a screen of German construction, and I guess it is along the same lines as the dewatering screens you are using now. We use wedge wires, and the minimum size opening is a quarter of a millimeter. In our experience, the cheapest way is still a dewatering bin. A dewatering bin takes 48 hr to do work that takes 20 min in a dewatering screen. We use old wedge wire from our driers which we cover with brattice cloth, and

* Lehigh Navigation Coal Co., Lansford, Pa.

* Battelle Memorial Institute, Columbus, Ohio.
† Jeffrey Manufacturing Co., Columbus, Ohio.

* H. C. Frick Coke Co., Pittsburgh, Pa.
† Pennsylvania State College, State College, Pa.
‡ Consulting Engineer, Vancouver, B. C., Canada.

in this way we have no losses.

The trouble with the centrifuge, as well as the dewatering screen, is that there is always an undersize, and the question is what to do with it? In some coals it amounts to a considerable tonnage. With the dewatering bin, we have no losses, and we arrive at about the same amount of remaining moisture, which varies according to the coal, from 10 to 16 pct.

So much for mechanical dewatering. Now for the drying. Some plants have to deal with that minus quarter millimeter. The practice in the old country is to treat those sizes by flotation and recover the coal by filter presses or disk filters like those used in mineral separation. Those machines are very expensive, and the remaining moisture is as high as 24 pct.

So, in most cases, you end up, very often, with heat drying. The flash type used for this drying is not new. This is called the Buttner-Rema-Rosin in Germany, and that type of drier has been in use there for 25 years. You can find it described in some reports made by some British Intelligence as well as, I think, American Intelligence. A very good description of the flash type of drier was given at the International Congress in 1935 in Paris. It is a far more complicated type of machine. It included a classifier, and the large sizes were ground again until they were able to go through. That is the reason why that type of drier was never very successful unless for a coke or briquette plant, because the amount of fines is increased, and coal below a hundred mesh is very difficult to work with. So there is still room for research work. At the present time, we think that we can do with the screen type drier just as good a job as is done with the flash type. The advantage of the screen type is that the fines go through the screen and there is an ascending current of hot air to dry them. The large sizes remain on the screen and can be carried out separately. In this way, crushing the coal is avoided, and that is important when handling bituminous coal.

V. F. PARRY*,†—The authors describe an economical method of recovering fine coal from washery sludges and slurries. I enjoyed reading the paper and found the presentation very interesting.

It is reported that total operating costs per ton of dry coal handled are 4.75 cents. This indicates a cost of 6.6 cents per ton of water removed from the slurry or sludge, assuming that the vibrating filters receive sludge containing 50 pct solids and reduce the moisture to 78 pct solids in the cake. It is estimated that the cost of removing water from lignite by evaporation is about 75 cents per ton of water removed under favorable conditions when lignite costs $1.00 per ton. If coal costs 15 cents per million Btu, it is estimated that the cost for evaporating a ton of water from coal will be about $1.00. Therefore, the advantage of mechanical filtering over evaporation in this instance is on the order of 1 to 15.

The vibrating filter appears to have a moisture-reduction limit of about 20 pct in the cake. This will vary with the size of coal and the distribution of sizes in the cake as pointed out by the authors. The average moisture in the filtered cake is about 22 pct and it may reach 28 pct when treating slurries. Coals of 22 pct moisture are penalized in utilization. It is somewhat difficult to handle the cake and to distribute it evenly in a coke-oven mix. Furthermore, the weight and latent heat of the moisture in the cake subtract considerably from the heating value. Reduction of the moisture in the cake from 22 down to 1 or 2 pct may have several advantages both from the standpoint of handling materials and from efficiency in utilization. I should like to present some discussion on the problem of reducing the moisture by evaporation, since this appears to be the only feasible way to remove the water remaining in the cake after mechanical filtering.

We have experimented for some time with high-speed drying of low-rank coals. These fuels contain bed moisture ranging from 15 to 50 pct, but this moisture can only be removed by evaporation. We have found that moisture can be removed at maximum speed by drying in the entrained and fluidized state, employing high-temperature products of combustion. Fine coal in the form of filter cake containing up to 90 pct moisture can be flash-dried with medium-temperature gases, such as is done in the Raymond flash-drying system illustrated in Fig 1 of the paper. In this system the cake is mixed with a portion of dried coal and then dispersed mechanically by a fan in the hot gas stream. Since the moisture is principally surface moisture, the evaporation is extremely rapid and the capacity depends upon the rate of supply of hot gas. In this system the temperature of the hot gas is limited to about 1300°F to avoid damage to the fan.

Hot gases at 2000 to 2200°F, and possibly higher, might be used for drying the filter cake, employing the technique we are using on low-rank coals. In this system the hot gases are generated under pressure and jetted into the fluid bed. Mechanical agitation in the bed could be employed to break up the filter cake without the addition of dried material. The thermal efficiency of such a system is 50 to 75 pct higher than that of the system previously discussed because of the higher-temperature hot gas and the possibility of excluding recycled dried coal. The capacity of a drying column employing the entrained and fluidized technique should be about 2000 lb of filter cake per hour per square foot. The net heat required to dry the coal is 316 Btu per pound, and the overall thermal efficiency of the drying system should be 85 to 90 pct. These estimates are derived from our experience in drying lignite of 37 pct moisture.

It is indicated, from studies we have made on costs of drying low-grade coals, that the moisture in filter cake can be removed at a cost of $0.75 to $1.00 per ton of moisture removed.

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Cyclone Operating Factors and Capacities on Coal and Refuse Slurries

By D. A. DAHLSTROM, Junior Member, AIME

DISCUSSION

(*A. C. Richardson and Charles C. Boley, presiding*)

W. E. BROWN*—In the operation of the cyclone, what factors have you found that will affect its results as far as efficiency goes; for example, if you have coming through the cyclone a pulp of 20 gpm, that has, say, 25 or 30 pct solids, and then from operational characteristics this pulp changes to 35 pct solids but it is still maintaining the same ratio of flow. How does that affect the cyclone?

D. A. DAHLSTROM (author's reply)—It has a definite effect, as you know from Mr. Sutherland's paper,[13] in that as you increase the solid concentration of your inlet slurry, you will naturally have an according effect on the overflow concen-

* Humphreys Investment Co., Denver, Colo.

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tration. This, of course, assumes that the amount of addition possesses the same size distribution—in other words, the size distribution of the heavier load is the same as the lighter load. The cyclone will tend to operate with about the same efficiency even though there is an increase in the loading. A very rapid complete overloading of the cyclone is not usually experienced. However, it will undoubtedly tend to go into a transition discharge for severe loadings unless there is some method of changing the underflow diameter. In this case the recovery undoubtedly will be injured to a certain extent.

There have been methods advanced for the use of a rubber joint at the bottom of the cyclone in order to be able to change the diameter of the underflow at any one time. I have not done any work at all on that, so I cannot answer that question, but we believe it is extremely important that the slope of the cone be maintained constant all the way down to the underflow discharge. As soon as the flow pattern of the cyclone is disturbed, the air current, which we think is important for the maximum elimination of solids, tends to shut off.

W. E. BROWN—Usually in an operation, a constant volume of pulp comes through any process, but the solids can vary considerably.

D. A. DAHLSTROM—Again I will have to go back to Mr. Sutherland's data, and you will observe that it would vary during a day's time, especially as you get a build-up of fine solids in your system. We found that the variation was not too great, that is, we did not have to go into any change in dimensions at all. We simply allowed them to stay put, and we did get a certain amount of damage to our percentage of extraction, because we progressed more and more toward the complete overloaded condition. However, it was not serious, I believe, and you could set your underflow dimensions to take care of, say, your average, or slightly larger than average, operating condition. It probably would take care of your peak periods and also would not give you too much dilution in periods when below average load.

J. D. GROTHE*—Your work was done essentially on homogeneous gravity solids?

D. A. DAHLSTROM—That is right.

J. D. GROTHE—The work at the collieries would be on heterogeneous gravity solids. Can you tell us the effect in this case?

D. A. DAHLSTROM—When you have a range of gravity material that is ranging from coal of, say, 1.3 up to pyrite of approximately 5.0, you will naturally have a range of 50 pct points. In other words, each particular particle of gravity has its own particular 50 pct point. That is why we had to standardize on standard specific gravity material for theoretical work, because we would have an introduction of too complex a variable by use of coal or refuse slurries.

In our analyses we use the hydrometer method proposed by the Casagrande, which assumes an average specific gravity of that fraction, and I might add that the method of hydrometer analysis has been used by soil mechanics and civil engineers, and is considered about as valid as any subsieve method. We found that this, tempered with a 1.25 safety factor, would give a suitable prediction of 50 pct points.

W. L. McMORRIS*—You made the statement that the cyclone could be used as a vessel for separation for particles of different gravity. You showed in your slides a differential between the 50 pct point of your standard material and that of a higher gravity material. Have you ever worked out, either experimentally or mathematically, the difference in the ratio of concentration shown in the cyclone as compared to the ratio of concentration in hindered settling or in free settling?

D. A. DAHLSTROM—May I change your question around to this: Have we shown any effect on the 50 pct point as we increase the solid concentration on the feed—does that sound logical?

W. L. McMORRIS—No. Let me give you an example. You made the statement that there would be a different 50 pct point on pyrite as compared to 1.3 gravity coal. If you apply the standard hindered settling formulas to 1.3 coal and, say, 4.9 pyrite, would the ratio of concentration that you obtain in the cyclone be as good as that which you obtain in hindered settling?

D. A. DAHLSTROM—We made no tests on that because we were entirely concerned with complete solid elimination with relatively dilute suspensions, and we found, as indicated, that when we used Stokes' law without any hindered settling considerations and obtained our correlations, we did as well as free settling. I do not know what would happen with hindered settling.

H. F. YANCEY† and M. R. GEER†—The cyclone paper by Fraser, Sutherland, and Giese,[13] and that by Dahlstrom are of great interest to us because the original work on the cyclone as a thickener of coal slurry was done by the Bureau of Mines at its Northwest Experiment Station in Seattle. The first paper is especially interesting because it represents plant operation as distin-

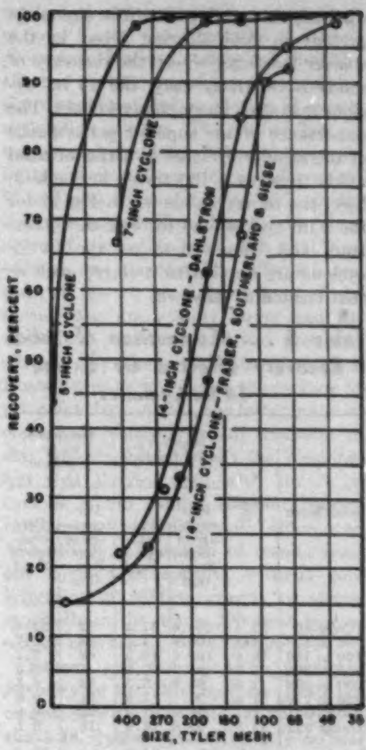

FIG 17—Comparison of solids recovery in 5, 7, and 14 in. cyclones.

guished from laboratory-test information. Dahlstrom's paper is concerned principally with cyclone design and provides information hitherto unavailable on the energy requirements of cyclones.

One of the most important conclusions he has reached is that cyclone diameter has no influence on the efficiency of recovering solids; in other words, large cyclones are as efficient as small units. This conclusion, however, does not appear to be substantiated by published data on cyclone performance, even including that provided by his own work. To illustrate this point, Fig 17 shows the performance of 5, 7, and 14 in. cyclones, expressed in terms of the percentage recovery of the individual size fractions comprising the feed slurry. Data for the 5 in. cyclone represent test 82 from our own published report,[8] and that for the 7 in. cyclone are from test 2 of Dahlstrom's discussion[8] of this report. Two curves are shown for the 14 in. cyclone installed at Kayford, W. Va., one representing an average of 10 tests reported by Fraser, Sutherland, and Giese, and the other illustrating an average of 5 tests on the same unit reported by Dahlstrom. All of these tests were made on coal slurries, and all are comparable in that they represent vortex discharges containing less than 16 pct of the water present in the cyclone feed.

These curves illustrate clearly the superior recovery effected by the smaller

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D. A. DAHLSTROM—That is right.

J. D. GROTHE—The work at the collieries would be on heterogeneous gravity solids. Can you tell us the effect in this case?

D. A. DAHLSTROM—When you have a range of gravity material that is ranging from coal of, say, 1.3 up to pyrite of approximately 5.0, you will naturally have a range of 50 pct points. In other words, each particular particle of gravity has its own particular 50 pct point. That is why we had to standardize on standard specific gravity material for theoretical work, because we would have an introduction of too complex a variable by use of coal or refuse slurries.

In our analyses we use the hydrometer method proposed by the Casagrande, which assumes an average specific gravity of that fraction, and I might add that the method of hydrometer analysis has been used by soil mechanics and civil engineers, and is considered about as valid as any subsieve method. We found that this, tempered with a 1.25 safety factor, would give a suitable prediction of 50 pct points.

W. L. McMORRIS*—You made the statement that the cyclone could be used as a vessel for separation for particles of different gravity. You showed in your slides a differential between the 50 pct point of your standard material and that of a higher gravity material. Have you ever worked out, either experimentally or mathematically, the difference in the ratio of concentration shown in the cyclone as compared to the ratio of concentration in hindered settling or in free settling?

D. A. DAHLSTROM—May I change your question around to this: Have we shown any effect on the 50 pct point as we increase the solid concentration on the feed—does that sound logical?

W. L. McMORRIS—No. Let me give you an example. You made the statement that there would be a different 50 pct point on pyrite as compared to 1.3 gravity coal. If you apply the standard hindered settling formulas to 1.3 coal and, say, 4.9 pyrite, would the ratio of concentration that you obtain in the cyclone be as good as that which you obtain in hindered settling?

D. A. DAHLSTROM—We made no tests on that because we were entirely concerned with complete solid elimination with relatively dilute suspensions, and we found, as indicated, that when we used Stokes' law without any hindered settling considerations and obtained our correlations, we did as well as free settling. I do not know what would happen with hindered settling.

H. F. YANCEY† and M. R. GEER†—The cyclone paper by Fraser, Sutherland, and Giese,[13] and that by Dahlstrom are of great interest to us because the original work on the cyclone as a thickener of coal slurry was done by the Bureau of Mines at its Northwest Experiment Station in Seattle. The first paper is especially interesting because it represents plant operation as distinguished from laboratory-test information. Dahlstrom's paper is concerned principally with cyclone design and provides information hitherto unavailable on the energy requirements of cyclones.

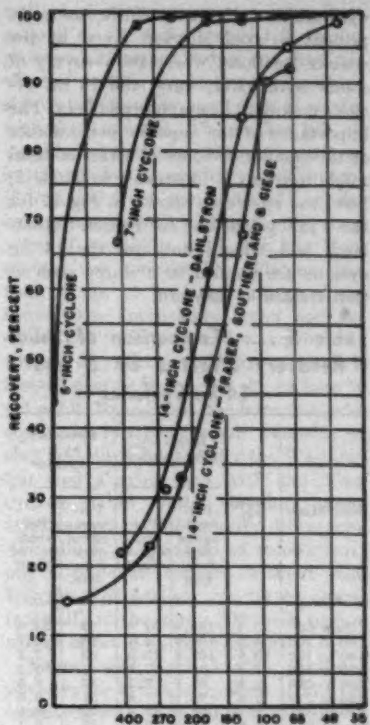

FIG 17—Comparison of solids recovery in 5, 7, and 14 in. cyclones.

One of the most important conclusions he has reached is that cyclone diameter has no influence on the efficiency of recovering solids; in other words, large cyclones are as efficient as small units. This conclusion, however, does not appear to be substantiated by published data on cyclone performance, even including that provided by his own work. To illustrate this point, Fig 17 shows the performance of 5, 7, and 14 in. cyclones, expressed in terms of the percentage recovery of the individual size fractions comprising the feed slurry. Data for the 5 in. cyclone represent test 82 from our own published report,[5] and that for the 7 in. cyclone are from test 2 of Dahlstrom's discussion[6] of this report. Two curves are shown for the 14 in. cyclone installed at Kayford, W. Va., one representing an average of 10 tests reported by Fraser, Sutherland, and Giese, and the other illustrating an average of 5 tests on the same unit reported by Dahlstrom. All of these tests were made on coal slurries, and all are comparable in that they represent vortex discharges containing less than 16 pct of the water present in the cyclone feed.

These curves illustrate clearly the superior recovery effected by the smaller

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cyclones throughout the entire size range present in coal slurries. Even in the coarser fractions, where the recovery of solids is relatively easy, the 14 in. cyclone makes an incomplete recovery. The importance of the superior performance of the smaller cyclones in terms of total solids recovery is illustrated in Table 5; here, the recoveries shown in Fig 15 for the 5 in. cyclone and for Fraser, Sutherland, and Giese's data on the 14 in. cyclone are applied to a slurry such as that treated at Kayford.

Table 5 . . . Comparison of Solids Recovery Effected by 5 and 14 In. Cyclones

Size, Mesh	Feed, Pct	Recovery, 5 In. Cyclone		Recovery, 14 In. Cyclone	
		Percentage of Size Fraction	Percentage of Feed	Percentage of Size Fraction	Percentage of Feed
Over 80	37.4	100.0	37.4	92	34.4
80 to 100	4.1	100.0	4.1	90	3.7
100 to 150	10.6	100.0	10.6	68	7.2
150 to 200	7.3	99.7	7.3	47	3.4
200 to 250	2.3	99.2	2.3	33	0.8
250 to 270	1.8	99.1	1.8	31	0.6
270 to 325	2.7	98.8	2.7	22	0.6
Under 325	33.8	55.0	18.6	15	5.1
Total recovery of solids			84.8		55.8

As shown, a 5 in. cyclone operating on this slurry would recover 84.8 pct of the solids in comparison with only 55.8 pct recovered by the 14 in. unit.

Thus, while from a theoretical standpoint it may be possible to operate large cyclones at velocities high enough to give the high recoveries characterizing small cyclones, in the pressure range commonly used the larger cyclones are distinctly less efficient. This argument should not be construed, however, to indicate that multiple small units are necessarily to be preferred to a single large cyclone. The cost of producing small cyclones equaling a larger unit in capacity may be greater, and in some instances the attempt to obtain complete solids recovery may not be justified economically. The advantage of the small cyclone is stressed here to correct any misconception about the relative efficiency of large and small units. Equipment manufacturers should consider the feasibility of producing small cyclones in multiple units for applications where maximum solids recovery is a justifiable objective.

Undoubtedly, Dahlstrom's conclusion about the relative efficiency of small and large cyclones was influenced largely by considering the 50 pct separation size, that is, the particular particle size divided equally between the two products, as a measure of the efficiency of solids recovery. Using this size as a criterion of efficiency, instead of using the information provided by the type of curves in Fig 15, is equivalent to characterizing the efficiency of a coal-washing process by the specific gravity at which the separation between coal and impurity is made, without any regard for the amount of heavy impurity entering the washed product or the amount of clean coal lost in the refuse.

Moreover, Dahlstrom's determination of the separation size is based entirely on a simple sedimentation method of estimating the size distribution of subsieve material. The dangers inherent in relying on such a method were pointed out in the reply to his discussion of our cyclone paper.[14] A concrete example of the errors involved in this procedure is provided by the data in Dahlstrom's test 6; complete data for this test were not included in his paper but were kindly furnished by him for the purpose of this discussion. In this test actual screen analyses showed the separation size to be about 100 microns, while the sedimentation-test data indicated a separation size of only 50 microns. This comparison is shown in Table 6, which shows the recoveries calculated from both screen analyses and sedimentation tests.

Table 6 . . . Recoveries Effected in Different Size Fractions, Dahlstrom's Test 6

Screen Analysis, Size in Mesh, U.S. Std.	Percentage Distribution		
	Feed	Overflow	Underflow
Over 4	100.0	0.0	100.0
4 to 10	100.0	0.0	100.0
10 to 20	100.0	0.0	100.0
20 to 40	100.0	0.5	99.5
40 to 60	100.0	1.4	98.6
60 to 100	100.0	6.5	93.5
100 to 140	100.0	29.7	70.3
140 to 200	100.0	53.3	46.7
Under 200	100.0	82.6	17.4
Sedimentation Analysis of Minus 200, Size in Microns			
Over 65	100.0	0.0	100.0
65 to 46	100.0	39.1	60.9
46 to 32	100.0	68.0	32.0
32 to 23	100.0	86.6	13.4
23 to 16	100.0	84.3	15.7
Under 16	100.0	92.0	8.0

Another anomaly is evident in the fact that sedimentation tests indicated that 100 pct recovery was effected in the sizes coarser than 65 microns, whereas the actual screen-analysis data indicated that complete recovery was effected only in the sizes coarser than 20-mesh, corresponding to 840 microns. Obviously there is no direct correlation between the equivalent diameters obtained by sedimentation tests and sizes determined by screening. With discrepancies of this magnitude inherent in the sedimentation method, it is clear that conclusions reached on the basis of its use must be regarded with great caution.

Another conclusion reached by Dahlstrom with which we are not in complete agreement is that the percentage of water entering the cyclone underflow has little bearing on the recovery of the finer solids. Actually, the data presented by Fraser, Sutherland, and Giese indicate clearly that, when the overflow orifice of the cyclone was restricted and hence a higher percentage of the water entered the underflow product, the recovery of solids was enhanced considerably. In fact, the common basis on which the performance of cyclones operating on different slurries can be compared readily is the distribution of the water to the overflow and underflow products; this distribution is controlled by the size of the cyclone openings. With a vortex-type underflow the actual percentage of solids in either the underflow or overflow products is dependent upon not only the percentage of solids in the feed, but also upon the size composition of these solids. Hence, comparisons based on thickening effect are not valid unless these factors are taken into consideration. The type of curves illustrated in Fig 15 represents the best means of comparing cyclone performance provided they represent similar percentages of the feed water entering the underflow product.

D. A. DAHLSTROM—Before commenting on Messrs. Yancey and Geer's discussion, it would be wise to first emphasize an important consideration of the original paper. The work was undertaken to obtain fundamental data and theory of the liquid cyclone which is of large importance in its fuller application and understanding. To achieve this it was felt that a special cyclone permitting individual observation of all operating and design factors would have to be constructed rather than use several different cyclones wherein all factors are simultaneously altered. Furthermore, as particle specific gravity is of major importance in such a separation process, industrial coal and refuse slurries which possess wide ranges in solid gravity could not be used. With this complex variable present, it would be very difficult to reliably determine individual factor effects. Therefore, a close gravity material was employed which would entirely eliminate this doubt. Accordingly, the experimental results and predictions can be expected to approach the ideal state and industrial performance may exhibit some deviation. However, fundamental studies are still of paramount importance in ferreting out the individual factors that effect any process operation which certainly cannot be reliably predicted from performance tests *alone* on industrial installations. (The emphasis is that the studies should complement each other.) In an effort to bridge the gap, the author has applied correlations of industrial data with experimental predictions so that the usual expediency of safety factors, where necessary, may be utilized.

For convenience of later discussion, reply will first be made to the objection of the hydrometer method for determin-

ing particle size. Any cyclone separation on minerals results in an appreciable concentration of the minus 200 mesh fraction. In fact, the 50 pct point (the validity of which will be discussed later) usually lies below the 75 micron size. Because of the proven unreliability of screen analyses below these dimensions, some subsieve method must be employed. The microscope cannot be used with sufficient accuracy for several reasons: (1) Only two dimensions are observed and a complex and exhaustive statistical analysis must be applied to determine a series of dimensions that portray size distribution. (2) If large ranges in solid specific gravity are present, it is almost impossible to correctly weight this factor. (3) The effect of particle shape cannot be reliably predicted. As particle shape is extremely important where surface area per unit mass is large (that is, fine sized particles), it would be misleading to determine elimination efficiencies based only on the linear dimensions of the particles and not consider particle shape or sphericity. (4) When materials are dried for microscope observations, it is difficult to prevent a partial, if not considerable, agglomeration of the individual particles, which introduces large errors.

From the above discussion, it is apparent that it would be desirable to utilize size analysis, employing liquid suspensions so that an equivalent particle dimension would be determined combining both particle size and shape. Settling velocity test procedures such as the hydrometer method have been found to be of considerable accuracy in this respect. The dependability of the test has been validated through exhaustive tests over the last 20 years and is now universally accepted by the soil mechanics and civil engineers. The proof and further development of Casagrande's original work[10] will be found in other works.[19-23] Today, these writers state the hydrometer method, when properly executed, is as accurate or better than any settling velocity method and generally will be appreciably simpler and time saving. Naturally, the accuracy will be decreased where large ranges in specific gravity are present. However, the tendency will be towards an averaging of specific gravity and all other methods will experience this same error.

Yancey and Geer, in Table 6 of their discussion, pointed out an apparent inconsistency in a hydrometer analysis; the screen analysis indicates a 50 pct point of about 100 microns while an hydrometer analysis on the minus 200 mesh fraction predicts 50 microns. This particular test run represents a severe deviation from normal operating conditions as a West Virginia cloudburst had completely muddied the natural streams used for make up water at this tipple. Solid distribution was altered and the ash concentration in the minus 200 mesh fraction increased from an average of 18 to 35 pct. Furthermore, as pointed out in the original paper, the underflow contained 58.3 pct solids, indicating a transition discharge. Thus, as the 50 pct point is a function of particle specific gravity, this point for the low ash coal was found at about 100 microns (exclusive of particle shape), while the high ash material point was located at 50 microns. This is further strengthened by the low ash concentration of 5.3 pct for the overflow 100 by 180 mesh fraction compared with 31.8 pct for the minus 180 mesh fraction. Finally, this was the only case of all the runs made, exclusive of complete overloading, that exhibited a 50 pct point for any of the material above the 200 mesh size.

Further objection was made (in their discussion) to the fact, "that sedimentation tests indicated that 100 pct recovery was effected in the sizes coarser than 65 microns, whereas the actual screen-analysis data indicated that complete recovery was effected only in the sizes coarser than 20 mesh." It must be remembered that hydrometer analyses were performed only on the minus 200 mesh fraction and extrapolation to the coarser sizes was not intended. Because there is a large range in specific gravity in this fraction with most of the heavy ash and pyrite material present in the underflow stream, hydrometer analysis on the underflow will tend to show a larger initial amount in the near 200 mesh size as one is forced to use an average specific gravity. By the same token, this near mesh material will appear to be absent in the overflow and thus will yield the anomaly. However, determinations at the 50 pct point for the *average specific gravity material involved* were proved to be dependable within 25 to 30 pct error, of theoretically predicted values. On the other hand, extrapolation of screen analyses in the minus 200 mesh region would be very dubious.

Considering the effect of cyclone diameter on degree of solid elimination, the author finds himself in disagreement with Fig 15 of Yancey and Geer's discussion. The portion of the curve below 270 by 400 mesh for the 5 in. cyclone and that below 140 by 200 mesh for the 7 in. cyclone was obtained entirely by extrapolation. This means extrapolating a curve established only from 100 down to 98.3 pct in the former case and to 98.9 pct in the latter, making any extension subject to considerable error. The curve representing the author's data on the 14 in. cyclone included 4 runs operating with a transition type underflow discharge in the 5 run average which were originally maintained to be inferior. The fifth run operating with a complete vortex discharge was definitely superior (run 3, Table 1 in the paper) with a 76 pct recovery of the total feed solids. This method of plotting is of course excellent as long as the same material is always processed. However, it does not show the effect of particle gravity on the resultant size distribution for prediction of results with other slurries. The author has always found that plus 200 mesh material in the overflow is very low in ash content (2 to 5 pct) when compared with similar sizes in the underflow. Finally, the character of the solids used with the 7 in. cyclone was considerably different than that of the 14 in. Ash content of the former was appreciably larger and the minus 200 mesh material was primarily silt and clay, the particle size of which is located near or well below the cyclone 50 pct point. By contrast, the latter material contained relatively small amounts of clay and silt. Undoubtedly the Washington coal slurries used with the 5 in. cyclone would exhibit singular characteristics and particle gravity differences. Accordingly, estimation of results from one cyclone to another without consideration of particle gravity or shape, especially in the minus 200 mesh region, will be affected by these factors.

Yancey and Geer show a predicted recovery for the 14 in. cyclone of 55.8 pct compared with their value of 84.8 pct on the 5 in. cyclone based strictly on size distribution without regard to particle shape or gravity. Thus their calculation ignores the difference in character between the two slurries on which the data are based, especially in the minus 200 mesh region. Furthermore, comparison upon their same basis using only run 3 (Table 1 of the paper) instead of the admittedly inferior average values which include 4 transition discharge runs would yield a predicted solid recovery of 72.1 pct. Run 4 of the same table which operated with almost the same moisture content in the underflow as the original 5 in. cyclone run quoted by Yancey and Geer would have a solid recovery by their method of prediction of 76.6 pct. This would appear by their own basis to greatly lessen the significance attached by Yancey and Geer to cyclone diameter.

The author must admit that he is largely influenced by the 50 pct point measurement in his statements regarding cyclone diameter. For theoretical work this method appeared favorable as it does portray the lower limit of size concentration efficiency. Regardless of what the size distribution of the particles above this point in industrial installations under normal operating conditions, the author has never encountered any significant concentration of material below this size. However, I am certainly willing to admit that cyclone diameter may have appreciable influences on the distribution of particles above the 50 pct point and I did not intend to give the opposite impression. Decrease in cyclone diameter may tend to decrease the percentage of particles above the 50 pct point found in

Table 7 . . . Actual and Theoretical Solid Recoveries for High-water Distributions to Cyclone Underflow

Runs 3, 4, and 5 of the paper

	Run 3	Run 4	Run 5
Total solids to underflow, pct	76.0	80.4	83.3
Total water to underflow, pct	11.8	23.9	30.1
Overflow water, run 3, now reporting to underflow, pct		$\frac{23.9 - 11.8}{100 - 11.8} \times 100 = 13.8$	$\frac{30.1 - 11.8}{100 - 11.8} \times 100 = 20.7$
Theoretical solid recovery increase over run 3, assuming no concentrating effect		$13.8(100 - 76.0) = 3.3$	$20.7(100 - 76.0) = 5.0$
Theoretical solid recovery, pct		$76.0 + 3.3 = 79.3$	$76.0 + 5.0 = 81.0$

the overflow. At the same time, the author believes the effect on the 50 pct point will be relatively insignificant. It should also be cautioned that recent work at Northwestern has indicated that cyclone retention time, percentage of cyclone radius covered by overflow and inlet nozzles, length of cylindrical section, shape of cyclone top, and position of the overflow point with respect to the inlet and top of the cylindrical section may be of appreciable importance which may further minimize the significance of cyclone diameter.

In regard to percentage of water entering the cyclone underflow, the author also believes that it does have a bearing upon the final recovery of solids. However, it is maintained that this effect is insignificant after a complete vortex discharge has been attained. Proof of this will be found in the results of runs 3, 4 and 5 of Table 1 in the paper. Run 3 possessed a normal vortex discharge recovering 76 pct of the solids with a water split to the underflow of 11.8 pct. Runs 4 and 5 were made with severe increases in water distribution to the underflow caused by the insertion of smaller overflow nozzles. Assuming that increasing volume split to the underflow has no concentrating effect on the solids and this excess water carries with it only those solids in the same dilution found in the overflow, a theoretical calculation for solids recovery in runs 4 and 5 can be made as shown in Table 7.

The slight deviation of theoretical values (assuming no concentrating effect) from actual results may be due to the test error, the smaller overflow nozzles and their advantageous effect on the correlating factor $\frac{(gpm)^{0.53}}{(be)^{0.88}}$ of runs 4 and 5, or a beneficial influence on the near 50 pct material. In the latter case, solid material which is very close to the 50 pct point will tend to concentrate largely in the inner cyclone spiral. Thus by directing more of this flow pattern to the underflow, some concentrating action will result. However, it will usually be small and at the expense of a higher moisture content of the underflow product.

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Application of Screening and classification for Improved Fine Anthracite Recovery

By W. J. PARTON, Member AIME

DISCUSSION

(A. C. Richardson and Charles C. Boley, presiding)

D. R. MITCHELL*—The Chairman mentioned that we have had many papers on cleaning of fine coal and treatment of wash water solids. There are, of course, two reasons for that. One is that we have legislation, particularly in the east, that is making us go into these things whether we want to or not.

It just so happens at the present time that I have four plants that are going up under my general direction, three new and one rehabilitation job, and in all of them, we have these problems. Therefore, I was very happy to be able to listen to these papers, because some of the things that are in them are going to help me solve some of the problems that I am facing.

Of course, the second reason why we are concerned about fine coal recovery is the fact that coal has become a luxury item in a good many places, particularly in the anthracite region, so that we cannot afford to have it go to waste like we did in former years.

There is a third minor reason, and that is that we are finding how to handle and use the extremely fine sizes that we did not know how to use in former years.

Now, I have a couple of questions that I would like to ask. First, what are the maximum solids that you could have in a pulp going to one of these launder screens? I realize that it would be for anthracite. Second, of course the life of these screen surfaces is not very long—with brass or bronze, I believe it is a week, and with stainless steel, a month. Would it be possible to use screen surfaces like the Bixby-Zimmer round rod for the small sizes and possibly increase the life? Have you experimented with that?

Another point that I would like to bring out, both in Mr. Parton's paper and in some of the others, in studying cyclones and any settling apparatus where we use orifices, the life of the orifices is very short, and that is a problem that still has to be solved. The capacity of the cyclone seems to be small, and if you have a bat-

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tery of them, there is one plant going up in central Pennsylvania that has a battery of cyclones, and if you have to have an attendant around those cyclones most of the time watching orifices, it is not so good.

At this meeting we have talked quite a lot about cyclones. There is another piece of apparatus that has been in commercial use on coal for several years, and it was mentioned, I believe, at the New York meeting, but we have had very little mention of it. That is a Vortrap. It was developed in the paper industry, and the recovery of solids is also by centrifugal force. It does seem to have a characteristic of not having quite as high abrasion, and the two that I know of that are in use also have much greater capacity. They are recovering solids from typical sludge tank overflows to a percentage as low as or lower than cyclones would in the same circuit. It is an apparatus that I think should be looked into by people having this problem. Of course, we do not know all about it. It needs a great deal of work on it, but it does not seem to have nearly the abrasion at the orifices that there is with cyclones.

W. L. McMORRIS*—As Mr. Parton said, there has been a lot of talk about classification of table feeds, and very little done about it. I think Mr. Yancey had something to do with it about twenty years ago along with Byron Bird, and the way was not entirely uncharted, but was full of reefs.

We did have a very tough coal problem. We had a high sulphur coal. We wanted to get an elimination of pyrite. We had to consider it as an ore dressing problem to recover the pyrite to make a metallurgical coal out of a high sulphur field. As far as cleaning the fines, it was further complicated by the fact that the coarse middling contained an abnormal amount of pyrite. The sulphur recovery curve plotted similarly to an ash recovery curve on a sink float basis showed a terrific hump in it between about 1.35 and 1.55 sp gr.

Experimental crushing indicated that that curve could be flattened and brought down to a normal curve if we were to crush that coal to pass ¼ in. and treat it by some other efficient method. We were afraid that ordinary tabling of fine mesh coal to which had been added a very substantial percentage of crushed middling would be impossible unless we took a leaf out of the ore dresser's book and used classification.

With some little help from us, a classifier was devised. It was an open bottom classifier, using a gentle vortex action in the rising column and a pinch valve for withdrawing the solids from the bottom of each cell. The pinch valve was designed by the Bureau of Mines for a single cell classifier and elaborated on for an eight cell unit which we put in. We have found that the classifier has done all and more than we expected of it. We are able to take a very respectable refuse from the first two cells without the tabling of those two at all. The products of the other cells go to tables and are discharged at a sufficient density that we have to add push water in order to get proper table feed density, which is a big advantage, and I think its lack was one of the things that was the cause of the failure of your work twenty years ago.

The overflow of the classifier is another problem. We still have to recover the minus 28 mesh overflow which we are doing through a large thickener and bringing that back to an additional battery of tables.

Our plant is brand new. We do not have very much in the way of metallurgical results. The size spread in the classification from the low gravity coal to high gravity pyrite is pleasingly broad, which makes the table separation, especially of the natural ¼ by 0, very good. We do have a lot of middlings on all of our tables, middlings which would still be middlings if it were crushed to pass 325 mesh, so we are having to make our cut in the middlings.

We have sink in our float coal and float in our sink. We have not yet determined where the economical point of that is going to be. We have to get together with our principal customer, Carnegie-Illinois Steel Corp., to find where we are going to make the cut. We do not know yet how much tonnage our tables will handle with this classified feed. We have tried to bog them down and have not been able to do it yet. The coarse coal end of the plant does not screen out the coal fast enough for us to over-load the tables.

We anticipated when we built this plant that our fine coal plant was going to be the bottleneck—the heavy media plant and the fine coal section are two separate and distinct plants as they now stand—but, much to our surprise, 75 pct of our table plant walks along with full rated capacity on the heavy media plant. Now we have to do something with the heavy media plant to make it catch up to the table plant.

But the classification of a table feed for a tough coal certainly has a lot of things to recommend it. Whether or not that could be used economically on a more simple washing problem is something else again, but for a tough one, we feel that the classification is going to pay off.

H. F. YANCEY*—This whole session has been extremely interesting to me, and I hope it has been to all of us. The papers have been of a high calibre, and so has the discussion.

Mr. McMorris's statement about the classification of the feed to coal washing tables is certainly interesting. We had the trouble that he spoke about in the work that I did with Byron Bird some years ago, that of having too much water in our classified products. They had to be dewatered ahead of the tables. But the thing of interest to me in his remarks is that he found it hard to overload the tables when using a classified feed, which is the very thing that we found. We had to dewater ahead of the table. Mr. A. C. Richardson, too, worked on this study at Seattle.

The further remark I would like to make concerns Mr. Parton's paper: I should like to compliment the Lehigh Navigation Coal Co. and Mr. Parton for releasing the information about this launder type screen. I feel that it is going to have great usefulness in the coal preparation industry.

W. J. PARTON (author's reply)—In the first place, answering Dr. Mitchell's questions, I do not know what the maximum percentage of solids in the feed could be to have the launder screen operate efficiently. I feel, however, that the maximum percentage of solids will be determined, to a certain extent, by the amount of oversize material in the feed. Since most of the water is lost through the deck, the percentage of solids in the oversize product will increase. Because the launder screen operation is based on having sufficient water to convey the oversize solids over the screen deck, sufficient water must be supplied either in the feed or at some point along the screen deck to do this.

An interesting application we are now planning to make with this screen is to make a 28 mesh cut in the feed discharge from the diaphragm pumps at the Tamaqua Colliery flotation plant. This feed product is being discharged into the plant at approximately 35 pct solids by weight. Just how this is going to work out, we do not know, but the only thing involved in the experiment is the time involved in having some carpenters make the launder screen. In this particular case, I believe we will find the use of some dilution water at the discharge end of the screen necessary to push the oversized particles from the screen.

Dr. Mitchell also asked about the possible use of Bixby-Zimmer cloth or wedge bar screen on the launder screen. Unfortunately, these types of screen cloth are not satisfactory. A square mesh cloth must be employed having approximately 50 pct open area, to prevent blinding. We have obtained what we feel is very good life with stainless steel cloth. I do not believe I mentioned it when I presented the paper, but the life of the stainless steel cloth is 450 hr as compared with 80 hr for bronze cloth.

Launder Screens

J. S. JOHNSON*—The cleaning and

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screening of fine anthracite, as Mr. Parton admits, is a difficult problem. It must be attacked in the field as circumstances present themselves. There is no iron clad rule that can be adopted.

I want to refer mainly to the launder screens which were first tried out at Nesquehoning Colliery. There is a very old saying, "Necessity is the mother of invention," and that was the case at Nesquehoning Colliery. The amount of water and fines to be handled and limited space between cleaning machines presented a problem of either installing vibrating screens and pumps or some other method of handling the large amount of water plus the fines flowing with the water.

It was here that Mr. Parton conceived the idea of the launder screens and the results, as shown in Table 2, are very good. Comparing Table 1 with Table 2, you will notice the feed tonnage for both tables is 60 tons per hour. The coal production is 29.8 tph for Table 2 and only 5.5 tph on Table 1.

This is a step in the right direction, to focus our minds and thoughts to stationary implements wherever possible. It is to be admitted that we are living in a machine age, but machines require rigid foundations and power to operate, along with maintenance of moving parts. The only maintenance on the launder is the stationary screen.

Fig 1 gives three views of this launder screen. The discharge orifices are really novel and interesting and actually act as a feeder when used between the different size cleaners, No. 4 and No. 5 buckwheat. In other words, these orifices help to take care of the surges which come intermittently in our preparation plants. As Mr. Parton has said, this type of screen can be used to remove excess water from a feed product ahead of cleaning equipment as well as removing the high ash fines from the feed material.

Fig 3 shows the set up of two laundry screens, one 3 by 18 ft before the cleaner and one 6 by 6 ft launder after the cleaner.

Fig 5 shows two launders in parallel with each launder having different mesh screens, the first one 16-mesh delivering No. 4 buckwheat over screen, and the second launder with 24-mesh screen delivering No. 5 buckwheat, each one to their respective cleaning tables.

It is to be understood that a complete study should be made regarding installation of stationary screens, tests procured giving amount of water and solids to be handled; also, very important is the analysis of the solids and of the ash by sizes. To get the best results the pitch on which the launder is installed will vary according to the amount and character of material to be handled.

Table 3 and 4 give results of tests made on parallel launders. The undersize to waste of the solids shows 8.84 pct with composite ash analysis 38.91 which shows there is some good material going to waste.

Fig 7 shows orifice design. Noting what Mr. Parton has to say about the length of service this is giving, I will suggest that rubber be tried out in the orifice as it has been my experience that rubber outlasts all metals and even glass, when properly installed.

Fig 8 shows oversize classifier. This is another interesting feature which Mr. Parton explains very thoroughly and will, no doubt, be improved upon in the near future.

All in all, I consider this paper a very excellent one and wish to compliment Mr. Parton on the way he has outlined the tests, figures and charts along with graphs and photographs.

Aerial Photographic Contour Maps for Strip Mines

By GEORGE HESS and R. H. SWALLOW, Member AIME

DISCUSSION

(L. C. McCabe and Robert P. Koenig, presiding)

C. G. BALL*—These maps are obviously quite helpful in many types of mining engineering, but I want to find out if the prints which you obtain in the first step toward making any aerial contour map have already been corrected for tilt. Is that done afterwards only if you are going into the process of making a contour map?

GEORGE HESS (authors' reply)—The tilt correction is the first step in either compiling the mosaic or compiling the total map. They must be corrected.

C. G. BALL—But are the contact prints themselves corrected for tilt?

GEORGE HESS—They are not corrected.

E. R. KAISER†—I enjoyed this paper very much, and am glad to learn that the methods have a high degree of accuracy and are in use in the coal industry. Accuracy in dimensions is understandable from the paper. Would you tell us how accuracy can be obtained in the vertical dimensions by means of the photographs so as to permit drawing contour lines?

GEORGE HESS—To explain our process, even in a limited way, is quite a large order. However, the basic principle involved is the measurement of parallax by viewing two overlapping photographs stereoscopically. It would almost be necessary to have the various instruments here on view to adequately explain their operation.

E. R. KAISER—Are the elevations for reference obtained at more than four points?

GEORGE HESS—The pattern of control is four points obtained in the corners. Primarily, that is to restitute the picture and horizontalize it. The vertical control points are read in on the stereometer and a direct comparison is made while drawing the contour lines. You do have to have those four points. But one stereoscopic pair of 5 ft contours has some 340 acres on it, consequently for every four points picked up 340 acres are contoured.

E. R. KAISER—How does your method compare with that used by the military reconnaissance during World War II?

GEORGE HESS—The Army did not get into this refined mapping. Most of their work has been reconnaissance mapping by taking one vertical and two oblique views. Basically, the same principle is used. Our maps are for engineering purposes. The Army was primarily interested in reconnaissance.

E. R. KAISER—You could take more than 48 pictures in one flight?

GEORGE HESS—Yes, the Brock camera accomodates 48 pictures per magazine. We are limited by the hours of greatest light, though, 2 hr before high noon, and 2 hr after high noon. Shadows do affect the picture. The shadows can-

* Paul Weir Co., Chicago, Ill.
† Bituminous Coal Research, Columbus, Ohio.

not be too long when contouring.

GEORGE ASHLEY*—One thing you did not mention is that if you do not quite get things on the map, you can turn back to the photographs instead of having to go back to the field.

GEORGE HESS—That is a very good point.

GEORGE ASHLEY—As a matter of fact, having used both photographs and maps made from them for several years now, I have, in recent years, used the photographs for field maps, and have made my station points on the photographs and then transferred them to the map. You can read the details much better, particularly if you use overlapping photographs, and the stereoscopic pocket lenses with them.

R. P. KOENIG†—I would like to emphasize the point Mr. Hess touched on. From the point of view of top management of a coal company or any other company, aerial mapping has great advantages. In the wintertime, one is sometimes hesitant in sending the engineers out to do topographic mapping, while one does not hesitate to send an airplane out. This gives the advantage of doing a job quickly without having to consider where you will get the ground engineers. Particularly if they are tied up on some other work, and it affords flexibility from the management point of view. This we found to be of great advantage. I think those of you who try this method further will come up with the same results.

* Consulting Engineer, Harrisburg, Pa.
† Ayrshire Collieries Corp., Indianapolis, Ind.

W. B. ROE*—These remarks are more a supplement to Mr. Hess' paper than to a discussion in that our use of aerial photographic maps has been entirely limited to use of existing photographs flown by the several Federal Government agencies such as the Soil Conservation Service, U. S. Geological Survey, Corps of Engineers, T.V.A., and others. Also we have had no outside work done on interpretation of the photographs, but have done our own plotting, and so on, with some very little outside consultation with people familiar with this kind of work. Consequently we have not produced or used any maps of the quality or accuracy described by Mr. Hess.

We first became interested in using aerial photographs in connection with our prospecting for lignite in North Dakota, principally because we needed reliable base maps of areas where no maps, other than small scale Land Office maps or state road maps were available.

Our first use of these photographs was to construct reasonably accurate maps on which to plot our prospect holes, land holdings, drainage, and so on, in these North Dakota areas. Little use could be made of the photographs in this area in mapping geology as the relief is quite low and the whole area is covered by surficial deposits which mask the actual bed rock except in very rare cases. They have been very helpful, however, in correcting property lines, locating drainage lines, divides, and other surface features. Use of stereoscopic pairs has also been quite helpful in tracing drainage and divide lines even though no actual elevations or topography have been taken from them.

* Truax-Traer Coal Co., Chicago, Ill.

Our use of aerial photographs in Illinois has been about the same as in North Dakota with about the same limitations due to similarity of terrain. However, they have been used to a lesser degree here because of the greater availability of recent fairly accurate topographic quadrangle maps and because our own property already had been pretty well covered by our own ground survey maps.

In West Virginia and other parts of the more rugged Appalachian coal fields we have used these photographs to quite some extent as in North Dakota and Illinois and also to a much greater degree as stereoscopic pairs in examining the geology of the region, as in these unglaciated areas the bed rock sequence and structure show up much more plainly in the photographs.

The stereoscopic pairs have been used for laying out tramroads, crop-line stripping, incline locations, and other uses, as looking at the pairs is second best only to a field examination of the area, and often discloses facts not discovered in the field, because of the impossibility of seeing the area as a whole when on the ground.

As stated in opening, this is hardly a discussion of Mr. Hess' paper, but does, I believe, show the possibilities of using the aerial photographs already in existence to facilitate prospecting and development of strip coal properties.

Coal Mine Development in Alaska

By ALBERT L. TOENGES, Member AIME

DISCUSSION

(*Richard H. Swallow and B. W. Dyer, presiding*)

C. P. HEINER*—I would like to ask Mr. Toenges about the highest rank coal. I did not get that clearly. What kind of coal is that?

A. L. TOENGES (author's reply)—The coal in the Matanuska field ranges from high volatile "B" bituminus to anthracite. It all depends on which direction you go in the Matanuska field.

C. P. HEINER—Is it a large reserve?

* Utah Fuel Co., Salt Lake City, Utah.

A. L. TOENGES—That is what we hope. That is what we are trying to find out.

B. W. DYER*—In those strip beds, I wonder how far back the coal would weather?

A. L. TOENGES—I never noticed particularly.

B. W. DYER—The weathering does not extend back like it does in this country?

A. L. TOENGES—No, it does not.

* U. S. Geological Survey, Salt Lake City, Utah.

B. W. DYER—Is that due to the freezing?

A. L. TOENGES—Probably so.

B. W. DYER—In this country, you would expect nothing but weathered coal.

R. H. SWALLOW*—Along that line, you mentioned some of the seams were on fire. Did you ever know how far back they burned, or was it hard to tell?

A. L. TOENGES—The fires occurred in the mine. That one you refer to was from an inside fire.

* Ayrshire Collieries Corp., Indianapolis, Ind.

H—Industrial Minerals

Beneficiation of Industrial Minerals by Heavy Media Separation

By G. B. WALKER and C. F. ALLEN, Members AIME

DISCUSSION

Why Differential Density Separation

K. F. TROMP*—In dealing with the question of the most suitable kind of solid media for heavy density suspension processes Walker and Allen point out that the particle size of the solid media should not be taken too fine, as the viscosity increases with the area of the solid media and a low viscosity is essential for high tonnage and accurate separation. A coarser particle size of the solid media will, in their opinion, of necessity give rise to a differential density in the bath (higher gravity at the bottom of the bath than at the top) but they advocate acceptance of the differential density rather than a higher viscosity.

Though I fully agree with the choice the authors have made, I cannot subscribe to their view that only by accepting a differential density in the bath a coarse particle size of the solid media can be used. There certainly is another alternative: stronger agitation. Applying sufficiently strong vertical currents, a uniform gravity can be obtained quite well in a suspension of a coarse solid media. Of course, this is not a very attractive solution, for it means a degradation of the true gravity separation and a step backwards to hydraulic classification, which makes the washing dependent on size and shape of the particles.

However, to a greater or lesser extent, this is what actually takes place in all the heavy density suspension processes relying on a uniform gravity in the bath. The so-called "stable" suspension processes make no exception. They all "stabilize" their suspensions by introducing or creating vertical currents, be it upwards or downwards or both, be it by hydraulic or by mechanical means. In fact, there is no such thing as a "stable" suspension in gravity separation, as the very reason for the use of suspensions in this field is the property that the solid media is able to settle and so facilitate the recovery.

I have been enlarging on this point because the characteristics of the various processes can only be well understood and viewed from the same angle (from Barvoys up to Chance) when the fact is recognized that mechanical or hydraulic agitation is a condition *sine qua non* for obtaining a uniform density from top to bottom in a suspension.

Is a Cone-shaped Vessel Essential?

Of the two alternatives for getting a low viscosity Walker and Allen have preferred correctly the sacrifice of uniform gravity in the bath instead of increasing further their vertical current and agitation. The resulting differential density of the bath brings the problem of how to prevent accumulation of intermediate gravity products in the bath, an accumulation which, if not prevented, would ultimately plug their cone. According to the authors an open-top cone combined with a downdraft current of the bath liquid would be the only suitable way to cope with such suspensions and they assume as a fact that "in any vessel other than a cone, such a differential density could not be tolerated."

My experience is quite different. In my process, which has been in successful operation for more than a decade, differential density of the suspension is applied ranging from values below 0.1 up to differentials above 0.5, according to the prevailing requirements of the individual plant. In this process, which is characterized by the use of horizontal currents in a suspension of differential density, the form of the vessel is of secondary importance and different types are in operation. It so happens that *none of these are in the form of a cone.* The fact that 24 washboxes on my process have been installed and 12 others are under construction may constitute sufficient proof against the opinion that only a cone-shaped separator would be suited for differential density separation.

Horizontal Currents in Differential Density Separation

I myself have some doubts as to the suitability of a cone with downdraft for dealing with differential density (or, for that matter, any other washbox relying on vertical currents for removing the intermediate gravity products). It appears to me that it is restricted to feed of small size only and even then with watchfulness. If we take, for example, a piece of 2 in., the draft necessary to pull such a piece down to a zone wherein the density of the suspension is, say, 0.03 higher, is quite considerable. For a suspension of, say, 1.6 sp gr the downdraft will have to be in the region of 3 in. per second.

Unfortunately, most of the differential in density is in the part immediately below the reach of the top current which transports the floats. Consequently, we need the downdraft where we like it least: in the upper part of the cone. This entails the risk that light float particles are carried away with the downward current. This current of, say again, 3 in. per second would carry particles up to 1.3 sp gr and ⅜ in. size into the 1.6 gravity zone. This is prohibitive. It is also prohibitive because a downdraft of 3 in. per second in the upper part of the cone would require a tremendous circulation of medium. Half way up a 20 ft diam cone, a downdraft of 3 in. per second would correspond with 8500 gpm.

With the downward current following the way of least resistance, the strength of the downdraft will not be exactly the same at different places of a cross area. If, as I anticipate, the center of the cone is favored, the strength of the downdraft will fall below the critical value near the

* Consulting Engineer, Kerkrade, Holland.

periphery and give rise to a ring of stagnant intermediate gravity products, unless still larger amounts of suspension are circulated.

This example may give an idea of the restrictions which have to be observed when trying to remove the intermediate gravity products from a suspension by means of vertical currents. It explains why only a small differential can be allowed when material other than small sizes are washed. A small differential in density means of necessity that either high viscosities or strong agitation have to be accepted. There is no way to get around the law of Newton.

In my process, conditions are quite different. The intermediate gravity products are removed horizontally instead of vertically. In other processes, the strength of the currents is all-important, as they have to oppose (upward currents) or to neutralize (downward currents) the effect of the gravitational forces on the suspended products. In my process, the suspended products are shoved, not lifted. They remain in a zone having a specific gravity equal to their own. This explains why a small velocity of the horizontal currents is sufficient. Whether the differential in density between the top and the bottom of the bath is small or great makes therefore no difference in the efficiency and reliability of the removal of the intermediate gravity products. Nor does the size of the products do so.

For further particulars on my process I would refer to the literature[1,2,3] and especially to the latest paper, written by Holmes,[3] who gives a clear analysis of the problems connected with heavy-media separation.

References

1. O. Schaefer: The Tromp Dense Medium Process for Coal Washing. *Colliery Guardian* (1938) No. 4068, 1073–1077.
2. C. W. H. Holmes: Notes on Specific Gravity Washing with Special Reference to the Tromp Process. *Colliery Guardian* (1939) No. 4120–4121. *Trans.* Inst. Min. Engr. (1939–40) **98** (5) 175–207.
3. C. W. H. Holmes: Notes on Coal Washing with Dense Media. *Colliery Guardian* (1948) No. 4563, 856–859.

G. B. WALKER and C. F. ALLEN (authors' reply)—The discussion by K. F. Tromp makes some assumptions with respect to the currents in heavy-media separation cones which are not borne out by actual operation on a commercial scale. The assumption is made that a very large upward rising current of the order of 3 in. per second would be necessary. Upward rising currents of very large magnitude are indeed encountered in cones using the Chance process, where the medium solids are relatively coarse and a very strong upward current of water is necessary, resulting in a separation which is correctly described as resembling, in some respects, a separation effected by hindered settling. In practical operation, in cones using heavy media, there are no vertical currents of comparable magnitude. The medium has so low a settling rate that the gentle stirring effected by medium return and removal of sink and float products maintains the suspension of medium solids. From a purely theoretical point of view, no suspension is absolutely stable unless the particles are all of colloidal size. However, the stability of the normal medium used in heavy-media separation processes requires such negligible agitation as compared to processes such as the Chance process that, for all practical purposes, the medium may be considered as stable, even though it is true that if the medium stands for enough hours, or days, it will slowly settle. The practical meaning of the expression "stable" was the one used in the paper.

Mr. Tromp assumes that unless a very strong downward current of the order of 3 in. per second exists, heavy-media separation cones would plug up with products of intermediate density. In practical experience in 43 commercial heavy-media separation plants treating a large number of different ores, and with a total hourly capacity measured in the thousands of tons, this problem is normally not encountered, even when treating material as coarse as 9 in. and as fine as 10 mesh, and the heavy-media separation cones are normally operated with an agitation which does not produce upward currents of any significant magnitude. Neither excessive viscosity, nor violent agitation have proved necessary in commercial practice to prevent plugging of heavy-media separation cones with particles of intermediate gravity.

To illustrate the ability of a cone type separator to handle near gravity material without difficulty we show in Table 1 the heavy liquid analysis of a coal recently cleaned on a continuous basis.

Table 1 . . . Heavy-media Feed

Product	Weight, Pct			± 0.015 Sp Gr	± 0.03 Sp Gr	Ash Assay, Pct		
	Indiv.	Cum. Float	Cum. Sink			Indiv.	Cum. Float	Cum. Sink
Calc. raw feed	100.00					14.00		
Float 1.32	32.24	32.24				7.43	7.43	
1.32 × 1.33	10.98	43.22	67.76			9.82	8.04	17.12
1.33 × 1.34	10.11	53.33	56.78	29.84		11.08	8.61	18.53
1.34 × 1.35	8.75	62.08	46.67	25.23	41.30	12.33	9.14	20.21
1.35 × 1.36	6.37	68.45	37.92	20.21	33.33	13.55	9.55	21.96
1.36 × 1.37	5.09	73.54	31.55	14.47	25.22	14.51	9.89	23.65
1.37 × 1.38	3.01	76.55	26.46	10.10	20.04	15.24	10.10	25.41
1.38 × 1.39	2.00	78.55	23.45	8.58	15.73	16.14	10.26	26.72
1.39 × 1.40	3.57	82.12	21.45	7.63	12.30	17.38	10.57	27.70
1.40 × 1.41	2.06	84.18	17.88	7.29	9.87	18.53	10.76	29.98
1.41 × 1.42	1.66	85.84	15.82	4.30	8.41	19.64	10.94	31.16
1.42 × 1.43	0.58	86.42	14.16	2.78	5.70	21.27	11.01	32.54
1.43 × 1.44	0.54	86.96	13.58	1.98	4.48	19.84	11.06	33.03
1.44 × 1.45	0.86	87.82	13.04	2.24	4.19	21.86	11.17	33.57
1.45 × 1.46	0.84	88.66	12.18	3.07	4.97	22.55	11.25	34.40
1.46 × 1.47	1.37	90.03	11.34	3.57		24.57	11.48	35.30
1.47 × 1.48	1.36	91.39	9.97			31.85	11.78	36.78
Sink 1.48	8.61		8.61			37.52		37.52

More recently an anthracite coal was treated in a continuous operation. The medium was adjusted so as to deliberately set up a high differential density. The specific gravity of the float medium was 1.65 while that of the sink medium was 1.95, a differential of 0.30. Of the total quantity of material between 1.65 and 1.70 sp gr in the feed less than 5 pct remained in the cone at the end of the test. This illustrates the ability of a constantly increasing downdraft in the cone to offset the teetering effect of even an extremely high differential density.

Mr. Tromp incorrectly assumes that the downdraft created by the removal of medium through the air lift will be reflected throughout the entire body of medium in the cone which is not the case. If a cone is discharging float over a weir carrying a 3 in. crest of medium we can safely assume that the actual zone of separation is not deeper than 5 in. If the medium discharged by the air lift is returned to the cone at a level more than 5 in. below the surface, there will be no downdraft in the separating zone. In fact if all or part of the float drainage medium is returned to an intermediate zone in the cone an updraft will be created toward the surface of the cone while a downdraft will exist from the point of medium return to the air-lift opening.

The Link-Belt float-sink concentrator referred to in our article and the Nelson L. Davis Co. heavy-media precision processor both employ a very mild rising current through the bath working in conjunction with a horizontal conveying current on the surface. The Akins separatory vessel operates with primarily a horizontal current having a slight rising component and employs a very high differential density. The highly successful operation of all four types of separatory vessels together with the fact that they differ so widely in their method of opera-

tion leads one to conclude that the success of heavy-media is due primarily to the development of a method for recovering and cleaning finely ground magnetic medium rather than to the manipulation of currents required by separating methods which attempt to make a sink-float separation in a hindered settling classification system.

Recent Trends in Asbesta Mining and Milling Practice

By MICHAEL J. MESSEL, Member AIME

DISCUSSION

(J. L. Gillson and A. B. Cummins, presiding)

W. P. MOULD*—Has consideration been given to the problem of retreating the 4,000,000 ton tailings pile to recover the very considerable amount of asbestos fiber that was lost over the years due to insufficient operation and poor recoveries? Also, what was known about the possible content of chromite and the sulphides of nickel and cobalt?

M. J. MESSEL (author's reply)—Consideration was given to the problem but nothing concrete has been done up to this time.

W. P. MOULD—I am certain the tailings contain a very considerable quantity of fiber, not all of which is in the shortest lengths, because in the milling of talc rock from a neighboring location having a common origin with the asbestos bearing serpentine source of the tailings pile, a concentrate carrying 15 pct Ni and Co in complex sulphides and constituting about $\frac{3}{10}$ of 1 pct of the talc rock was recovered.

In the belief that the tailings also contained an appreciable content of chromite (then in demand, 1937) it was suggested to the management of the asbestos company that a truck load of the current tailings be sent to the flotation plant of the talc company where it would be put over the concentrating tables in an effort to discover the presence and roughly the percentages of chromite, nickel, and cobalt.

Preparations for the test were woefully inadequate and the test was completely snarled up by the surprisingly large quantity of asbestos fiber from 1 in. long down to very short fiber, all of which matted up and plugged launders and pumps with disastrous effects and practically the total loss of the sample.

If anything was indicated by the test, it was that a wet process for milling asbestos was worthy of very serious consideration.

M. J. MESSEL—A wet milling process for tailings retreatment only, is at present under study at our plant.

One asbestos mining company in Canada has constructed a fairly large test plant for this purpose, but as yet no definite results have been obtained other than in a small test unit plant which were in some respects quite encouraging.

* Rock of Ages Corp., Barre, Vt.